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Crew Factors in Flight Operations XII: A Survey of Sleep Quantity and Quality in On-Board Crew Rest Facilities

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September 2000

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1.0 Operational Summary

This report is the twelfth in a series on physiological and psychological effects of flight operations on flight crews, and the operational significance of these effects.

Long-haul flight operations often involve rapid multiple time zone changes, long and irregular work schedules, sleep disturbances, and circadian disruption. These factors can result in fatigue, cumulative sleep loss, decreased alertness, and degraded performance. Thus, operational effectiveness and the safety margin may be reduced by pilot fatigue. Federal Aviation Regulations (FARs) require that flights longer than 12 h. carry augmented crews so that crewmembers can rotate off of the flight deck for rest periods during cruise. Many aircraft operated on such flights are equipped with on-board crew rest facilities, or bunks, to allow crewmembers to lie down and sleep during rest periods. Sleep during long-haul flights is an operational countermeasure to fatigue that has been shown to improve subsequent alertness and performance (ref. 1).

Although many anecdotal reports about bunk use exist, there have been no empirical data about the effectiveness of crew rest facilities as an alertness management strategy. The National Aeronautics and Space Administration (NASA) was requested by the Federal Aviation Administration (FAA) to conduct a study examining the effects of noise in on-board crew rest facilities during long-haul transport operations. The general lack of data on bunk usage suggested to investigators that the study should examine broader issues as well, including how crewmembers use the bunks, the quantity and quality of sleep they obtain, the factors that promote or interfere with bunk sleep, and the effects of bunk use on subsequent alertness and performance.

The study was designed to be conducted in two phases. The first phase of the study was a survey study to collect data on flight crews, home sleep habits, bunk usage during operations, flight crew perceptions of factors that promote or interfere with bunk sleep, and flight crew attitudes about the facility and its efficacy. This report describes the survey findings, which informed the focus of the second phase of investigation. The second phase was an in-flight field study to collect physiological and subjective data on the effectiveness of bunk facilities as an alertness management tool. The results of the second phase study are reported in a separate document.

The survey study examined long-haul crewmembers from three participating U.S. airlines operating long-haul aircraft with bunk facilities. In each case, both the airline and the pilot union endorsed pilot participation in the study. The three carriers operated three types of aircraft with different bunk facilities. Two carriers operated mixed fleets of B747-100/200s and B747-400s (the latter of which has a more technologically advanced “glass” cockpit), and the other carrier operated MD-11s.

The retrospective paper-and-pencil survey consisted of 54 questions[1] of varied format and focused on demographics, home sleep, and bunk sleep (see Appendix 1 for the complete survey). Surveys were sent to a contact at each carrier, who distributed them to appropriate crewmembers. Participation was voluntary, anonymous, and confidential. Crewmembers were instructed to return completed surveys in the provided envelopes, which were postage-paid and addressed directly to NASA investigators.

Carrier 1 pilots completed and returned 737 surveys of 2125 sent (35% return rate); 107 were returned of the 220 sent to Carrier 2 (49%); and 560 were returned of 1500 sent to Carrier 3 (37%), for a total of 1404 completed surveys (36.5% return rate).

Demographically, the three carriers were comparable, though Carrier 3 had older, more experienced crewmembers. Most respondents (99%) were male, with average ages for the three carriers being 45 yr., 48 yr., and 51 yr., respectively. On average, about 90% of the

[1] Six questions were added to the survey sent to Carriers 2 and 3, making the total number of questions 60.

subjects from each carrier rated themselves as "good" or "very good" sleepers at home.

Comparisons between aircraft types revealed some significantly different responses concerning the bunk and bunk sleep. The older B747-100/200 series received notably poorer assessments than each of the newer aircraft. The '100/200 group reported more frequent difficulties sleeping in the bunk, gave the bunk a poorer overall rating than each of the other groups, and compared to the MD-11 group, rated turbulence as more interfering with bunk sleep. The MD-11 group returned the most positive ratings. MD-11 crewmembers reported the fewest problems sleeping in the bunk, gave the bunk the best overall rating, and reported the most improvement in alertness and performance as a result of bunk sleep.

Over three-quarters (81%) of the subjects who rated themselves as being good home sleepers reported difficulties sleeping in the bunk. On the other hand, those who rated themselves as poor sleepers at home nevertheless reported an average bunk sleep duration of nearly 2 hours (1 h.52 min.), which suggests that despite any perceived shortcomings of the facilities, crewmembers were able to sleep.

The list of factors identified as promoting sleep at home was almost identical to the list of factors promoting sleep in the bunk, and included pillows, blankets, and readiness for sleep. Likewise, the factors reported to interfere with sleep at home and with sleep in the bunk were very similar and included random noise, thoughts, heat, and trips to the bathroom. Interestingly, random noise was identified as an interfering factor with much more frequency than constant background noise, which indicates that the character of a noise, and not just its volume, may be an important consideration.

The findings suggest that bunk sleep may be improved by maximizing physical comfort and by minimizing random noise. Some potentially helpful changes may be straightforward, such as providing comfort items in the bunk (e.g., pillows and blankets) or requesting that flight and cabin crews minimize random noise events (e.g., service carts hitting the bulkhead or cockpit door closings). The data also suggest the possibility for more involved approaches, such as locating rest facilities farther from busy passageways; training crewmembers in relaxation techniques to minimize racing thoughts; providing better environmental controls in the bunk; and locating a crew lavatory nearby. Additionally, educating crewmembers in basic sleep physiology and alertness management strategies would enable them to plan their sleep efficiently, and to use other strategies effectively to enhance their sleep at home and in the bunk. The education of schedulers, management, and other industry members concerning fatigue issues and strategies may also provide important support for maximizing crewmember rest and alertness.

2.0 Introduction

2.1 Fatigue in Long-Haul Operations

Commercial long-haul crewmembers routinely face rapid multiple time zone changes, long and irregular duty schedules, sleep disturbances, and circadian disruption. These events can result in fatigue, cumulative sleep loss, decreased alertness, and degraded performance which, in turn, have the potential to reduce operational effectiveness and the safety margin. Thus, crewmember fatigue in commercial long-haul operations presents a substantial safety concern.

Many sources validate this concern. Numerous studies have shown fatigue-effects in long-haul commercial crews, including alertness and performance decrements and unintended napping (e.g., refs. 1-3). The NTSB identified fatigue as a probable cause in an aircraft accident involving a DC-8 in Guantanamo Bay, Cuba in 1993, and as a contributing factor in the 1997 Korean Air accident in Guam (refs. 4-5). Incidents reported to the NASA Aviation Safety Reporting System (ASRS), a confidential reporting system for flight crews and others who operate in the National Airspace System, have identified fatigue as a significant safety issue (ref. 6). As global travel becomes

increasingly common, and as the NAS becomes more crowded, the safety margin may leave less room for human error. Analysts project that commercial long-haul travel will continue to grow in the coming decades, with some of the highest annual growth rates for U.S. flag carriers occurring on routes between the U.S. and Latin America (average growth 6.3% annually between 1999–2010) and the Pacific (6.1%) (ref. 7). The increased demand on equipment and on the airspace system may serve to magnify the importance of alert, highly performing flight crews.

FAR Part 121 requires that flights longer than 12 h. carry augmented crews. When crews are augmented, a crewmember can rotate off of the flight deck for a rest period during cruise, while another crewmember fills the position. Many aircraft operated on such flights are equipped with on-board crew rest facilities, or bunks, to allow crewmembers to lie down and sleep during rest periods. A bunk facility may consist of: two sleep surfaces, either in upper/lower "bunk-bed" configuration or one horizontal bunk and one fold-down seat; bedding items; an area for storage; curtains separating bunk sleep surfaces; and a door separating the bunk from the rest of the cabin. If the crew is augmented by more than one crewmember, then two crewmembers may use the bunk facility at the same time (i.e., be "bunk partners"). The scheduling of bunk periods is generally at the captain's discretion.

Sleep is critical because it is the only physiological mechanism that can reverse, rather than simply mask, sleepiness. When available to crewmembers, as on augmented flights, it is an invaluable alertness management tool. As an operational countermeasure to pilot fatigue, sleep has been shown to improve subsequent alertness and performance, and to prevent "dozing off" (ref. 1). Yet while anecdotal evidence suggests that crewmembers use the rest facility to sleep, there have been no empirical data documenting its effectiveness.

The primary objective of this study was to determine how crewmembers used the bunk, to document the quantity and quality of sleep they obtained in the bunk, and to identify the factors that affected bunk sleep.

2.2 Physiological Background

Augmentation and the use of on-board crew rest facilities are presumably intended to maximize the safety of flight by maintaining an alert, high-performing crew on the flight deck. Fatigue, alertness, and performance are physiologically determined. A basic understanding of two physiological factors—sleep and the internal body clock (called the circadian clock)—are necessary background information. Together, sleep and circadian rhythms play a fundamental role in determining fatigue and alertness at a given time. Therefore, factors that affect sleep or the circadian system have the potential to affect fatigue, alertness, and performance as well.

Sleep is a vital physiological need. Most individuals require about 8 hours of sleep each day. When a person loses sleep, essentially all aspects of functioning can suffer, including alertness, performance, and mood. Sleep loss can degrade cognitive processes, vigilance, physical coordination, judgment and decision making, communication, outlook, and countless other parameters (refs. 8–9). In fact, research has demonstrated that 1 hour of sleep loss can affect waking alertness, and that 2 hours of sleep loss can significantly affect both alertness and performance (ref. 10). Sleep loss, over time, accumulates into a sleep debt, which can exacerbate the effects of acute sleep loss.

Sleep is a complex process, influenced by many factors. The quantity and quality of sleep
an individual obtains at a given time depend on prior sleep and wakefulness, time of day, age, and environment. Further complicating the matter, these factors interact with one another.

The basic concept behind the influence of prior sleep/wake patterns is the following: when individuals don't sleep, they become sleepy. That is, a homeostatic drive to sleep builds from

the time of awakening until the next sleep, just as the drive to eat (hunger) builds between one meal and the next. The longer the period of time since sleep, the stronger the drive to sleep. Conversely, the homeostatic drive is weaker shortly after sleep. A very long period of continuous wakefulness can create an intense sleep drive and associated sleepiness. When the drive for sleep becomes strong enough, it can send the brain and body into spontaneous sleep, regardless of whether sleep is appropriate or safe under the circumstances.

Almost every aspect of sleep changes with age. In general, the quantity and quality of sleep decrease with age. While older people do not necessarily need less sleep, they tend to obtain less sleep at night, have more nocturnal awakenings, truncate sleep in the morning, and nap more during the day. Therefore, the age of crewmembers may affect their experience of sleep, fatigue, and alertness.
The sleep environment also plays a large role in the quantity and quality of sleep. Dark, quiet surroundings and a comfortable temperature and sleep surface are key elements for a sleep-conducive environment (ref. 11). Because individual preferences differ widely, the ability to adjust the environment for comfort is an important consideration. However, even with an ideal sleep environment, sleep may be difficult due to stress, thoughts, or worries.

The ability to sleep also varies with the circadian rhythm of sleepiness. The term "circadian rhythm" (from Latin *circa* "about" and *dies* "day") refers to the cycle of a physiological function that repeats approximately every 24 hours. Virtually all functions of the body (e.g., sleep/wake, digestion, immune function) are controlled by circadian rhythms, which are regulated by the circadian clock in the brain. Generally, the body is programmed to sleep at night and to be awake during the day. Additionally, humans have two times of maximal sleepiness and two times of peak alertness each day. At approximately 3–5 a.m. and 3–5 p.m., sleepiness peaks, and sleep may come more easily. These times correspond to lower levels of alertness and performance. Conversely, at about 9–11 a.m. and 9–11 p.m., alertness and performance peak, and it may be difficult to obtain sleep, even if sleep-deprived. Time-of-day fluctuations in performance have been observed in several unrelated operational settings (ref. 12).

The circadian system cannot adjust immediately to changes in the work/rest schedule or time zone. When such changes occur, the circadian system is desynchronized from the environment for a period of time, and individual rhythms are out of sync with one another. Circadian disruption caused by irregular schedules or time zone changes can lead to sleep loss, performance decrements, worsened mood, digestive upset, and other symptoms. It can take from days to weeks for the circadian clock to resychronize completely.

Clearly, a range of physiological factors can influence sleep in the bunk, and consequently, affect fatigue, alertness, and performance. Understanding how rest facilities affect crewmembers' sleep provides a means to maximizing its benefit. Well-rested, alert flight crews, in turn, can enhance operational effectiveness and flight safety. There is no simple solution to fatigue in commercial air transport. However, by augmenting crews and utilizing on-board crew rest facilities to help manage fatigue and alertness in long-haul flight operations, the industry takes an important step in maintaining or improving the safety margin.

3.0 Methods

The initial survey comprised 54 questions of varied format, including multiple-choice, short written responses, and fill-in-the-blank answers. The survey was divided into three sections: "General" (basic demographics—14 questions), "Sleeping at home" (20 questions), and "Sleeping in aircraft bunks" (20 questions). Six questions were added to the version administered to Carriers 2 and 3 to gather additional information regarding bunk sleep. See Appendix A for the complete survey. Survey results can be found in

appendix B for Carrier 1, in appendix C for Carrier 2, and in appendix D for Carrier 3.

Three airlines were invited to participate in the study. In each case, the airline management and the pilot union management signed a letter of agreement endorsing pilot participation. Each airline reported the number of pilots flying long-haul aircraft equipped with bunks, and the corresponding number of surveys was sent to a contact at each airline for distribution to the crewmembers. Accompanying each survey were a cover letter, a copy of the letter of agreement, and a stamped return envelope. The cover letter explained the study and emphasized that all information provided by subjects was anonymous and confidential. The letter of agreement was included to communicate the support and commitment of both management and union. The envelope, addressed to NASA, was included so that completed surveys were returned directly to the investigators, helping to ensure anonymity and confidentiality for both the respondent and the airline.

The carriers operated three types of aircraft, each with different bunk facilities. Carriers 1 and 3 operated mixed fleets of B747-100/200 and B747-400 ("glass" cockpit), while Carrier 2 operated MD-11's. Therefore, comparisons were possible among different aircraft as well as among different carriers.

The survey posed questions that addressed general demographics, sleep habits at home, and experience with sleeping in on-board bunks. Targeting this broad spectrum was intended to identify factors that relate to an individual's ability to sleep in the bunk, and to provide a mechanism by which to compare bunk sleep with normal home sleep. Additionally, some questions were designed to assess the effects of bunk sleep on flight crew alertness and performance.

The "General" section on basic demographics requested personal information such as age, gender, height, weight, and family at home, as well as professional information such as flight experience and total flight hours.

Questions on "sleeping at home" addressed the subject's average night of sleep, including sleep timing, nocturnal awakenings, sleep problems, and the use of sleep aids. A key component of this section was a question that provided the subject with a list of 18 factors and asked how each affected sleep at home. The factors were rated on a 5-point scale from 1–"interferes" to 5–"promotes," with a middle rating of 3–"no effect."

The questions concerning "sleeping in aircraft bunks" requested information based on personal experience in the aircraft bunks. Questions targeted such data as sleep duration, difficulty sleeping, factors determining bunk usage, factors affecting bunk sleep, and how bunk sleep affected subsequent alertness and performance. A key component of this section was a question asking subjects to rate a series of 25 factors on how each affected sleep in the bunk. The question was designed for ready comparison with ratings of factors affecting home sleep, and listed the 18 factors from the home sleep questions plus 7 factors specific to bunk sleep.

Most questions were multiple-choice, which allowed for basic quantitative statistical analysis. Open-ended questions that required fill-in responses were analyzed by categorizing the comments from each question and then tallying them. Categories were developed according to the responses given.
All data then were entered into a modified Relation Information Management (RIM) database on a VAX 11/750 computer. Data manipulation and generation of graphics were performed using the S-Plus package (Statistical Sciences Inc, Seattle, WA). Analysis of variance, t-tests, principal components analysis, and equality-of-proportion tests were conducted using S-Plus and BMDP statistical software (University of California, Los Angeles).

To facilitate analysis of variance, multiple-choice responses with word-based scales were converted into a numerical code. Answers

were coded from 1 to 5, in order of the responses as they appeared in the survey (see Appendix 1). Lower values indicated "negative" or "less frequent" responses, and higher values corresponded to "positive" or "more frequent" responses.

4.0 Results

Crewmembers from all three carriers combined returned a total of 1,404 completed surveys of the 3,845 that were distributed (36.5% response rate).

4.1 Carrier 1

Crewmembers from Carrier 1 completed and returned 737 surveys of 2,125 sent (35% response rate).

4.1.1 Demographics

Carrier 1 responses (see Appendix 2) were received from 303 captains (41%), 276 first officers (38%), 147 second officers (20%), and 5 international relief pilots (< 1%). About two thirds of the group (69%) were flying the B747-100/200 series, while almost a third (31%) was flying the B747-400. Total flight hours averaged 12,522 h., ranging from 400 to 30,000 h. Crewmembers' experience flying long-haul operations averaged 8.8 years and ranged from one month to 40 years.
The sample consisted of 727 males (99%) and 10 females. The average age was 44.5 yr., and ranged from 27 to 63 yr. (only one subject, a flight engineer, was over age 60). The average weight was about 184 lb., ranging from 117 to 300 lb. The average height was 71.3 in. (range = 63–79 in.).
The Pacific time zone was the most frequently reported home time zone (42%), and the Central time zone the second most common (32%). A majority of crewmembers (89%) reported having a regular sleeping partner, and about half (48%) had children under the age of 18 living at home.

4.1.2 Sleep at Home

Data on home sleep habits were analyzed for the 737 subjects. The average bedtime was 2258 h. (10:58 p.m.), and the average get-up time was 0719 h (7:19 a.m.). Crewmembers reported that it took almost 20 minutes to fall asleep (mean = 19.4 min.) and that they usually awakened 1 or 2 times during the night. The 671 responses to an open-ended question on the causes of awakenings were grouped into 6 categories. The most frequently reported causes were physiological needs (420 reports), which included awakening to use the bathroom, and disturbances from family members or pets (103). After awakening, it took subjects an average of 12.8 minutes to go back to sleep. The average total sleep duration was 7 hours 47 minutes. More than half of the group (55%) reported "never" or "seldom" taking a nap during the daytime. Nearly two-thirds (64%) reported "never" or "seldom" having problems getting to sleep.

Respondents rated 18 factors on how each affected home sleep, using a scale from 1–"interferes" to 5–"promotes" (with a middle rating of 3–"no effect"). These ratings were examined in two ways: (1) the frequency with which each factor was rated at the extreme ends of the scale and (2) the mean rating.

The factors most often identified as promoting sleep (i.e., rated 5) were comfort aids: sleep surfaces (15% of all "promote" responses), pillows (15%), sheets (10%), and blankets (10%). Readiness to sleep, representing the physiological component of the ability to fall asleep, was the third most frequently cited factor and accounted for 13% of all "promote" responses.

The factors most often rated as interfering with sleep (i.e., rated 1) were thoughts (19% of all "interfere" responses), heat (15%), random noise (11%), and trips to the bathroom (10%). Responses for all factors were converted onto a scale from -2 to 2 (i.e., 3 was subtracted from each response value on the 5-point scale), so that factors identified as interfering (originally rated as 1 or 2) were expressed as negative scores, factors described as having no effect were expressed as zero, and factors identified as promoting (originally rated as 4 or 5) as positive scores. The mean scaled ratings are shown in Figure 1. These findings were reinforced by the 82 responses to an "other

(specify)" comment question ending the list of factors. The responses were grouped into 4 categories, all of which were cited by subjects as promoting sleep: environment (35 responses), comfort (20), good mental attitude (16), and physical activity (11).

Respondents were asked to rate four additional factors for the degree to which they interfere with sleep at home, using a scale of 1–"strongly interferes" to 5–"no effect." "Personal worries" was cited most as interfering with sleep, with 60% of subjects rating this as 1 or 2 on the scale, followed by thirst (42%), and hunger (28%). More than half (51%) rated respiratory factors as having "no effect." An open-ended question asked for additional interfering factors. The 81 responses were grouped into 5 categories, with the most common responses being jet lag (29 responses) and noise (14).

An open-ended question asking subjects to list factors that promote home sleep yielded 1105 responses, which were grouped into 8 categories. Crewmembers most often identified the following factors as promoting sleep: comfortable environment (336 responses—nearly a third of all responses), good mental attitude (180), pre-sleep activities (156), exercise and physical activities (137), and personal comfort (129).

A great majority of the group (94%) reported "never" or "seldom" using medication as a sleep aid. Of the 92 respondents who reported using medication to help them sleep, 50 used cold remedies or aspirin (the mostly commonly reported medications), and 39 used sleeping pills. A majority (88%) reported "never" or "seldom" using alcohol to help them sleep.

More than 91% rated themselves as "good" or "very good" sleepers. Most of the group (89%) reported that they had no sleep problem. The 73 pilots who reported having sleep problems cited circadian disruption (32 responses), being a restless sleeper (19), and snoring and sleep apnea (10) as problems. Only 6 pilots reported having had their sleep problem diagnosed by a physician, and only 6 reported that the sleep problem had prevented them from flying a scheduled trip.

4.1.3 Bunk Sleep (B747-100/200 and B747-400 aircraft)

In the year preceding the study, each subject used the crew rest facility on his or her current aircraft an average of 21 times and used the

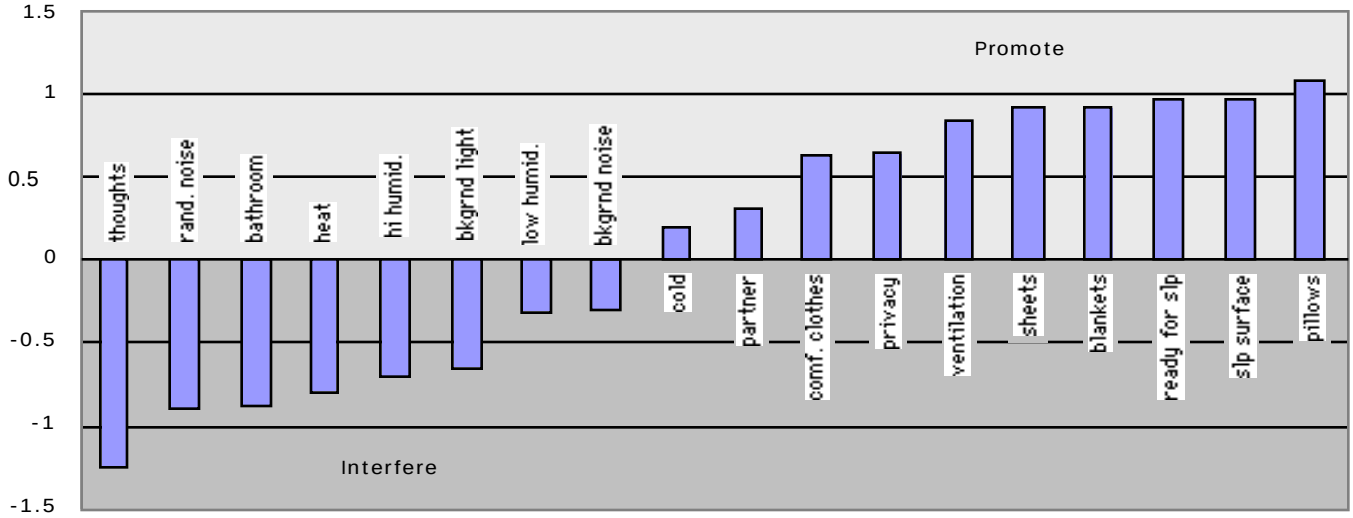


Figure 1. How various factors affected sleep at home (Carrier 1).

facilities in other aircraft an average of 1.59 times. When asked which bunk they usually used, respondents were about evenly split, with 36% reporting use of the upper bunk, 31% the lower bunk, and 33% reporting either bunk.

Most (88%) reported having the opportunity to undress for a more comfortable sleep, and about the same percentage (81%) reported that it was important for them to undress for a comfortable sleep in the bunk. Crewmembers reported that it took them an average of 44 minutes to fall asleep (range = 2–180 min.). More than half (54%) reported difficulty falling asleep in the bunk “often” or a “majority of time.”

Ninety-three percent of the subjects reported that there were no requirements for them to use the bunk. An open-ended question on the factors determining bunk use and rostering received 593 responses, which were grouped into 7 categories. Seniority and crew decision were cited in 229 responses (38%), identifying it as a principal determinant. Ninety-nine (17%) cited that crewmembers alternated choice, 82 (15%) identified the schedule or direction from the flight operations department as a factor, 75 (13%) cited sleep and circadian factors, and 70 (12%) listed augmentation. Crewmembers reported, on average, that 33% of cruise time was allocated for each individual to use the bunk.

When asked about their overall attitude about the bunk, nearly half of the group (49%) indicated a “positive” or “very positive” attitude, another 20% gave it a neutral rating, while slightly under a third (31%) gave a “negative” or “very negative” rating. Most of the group (86%) reported that alertness was “improved” or “very improved” by using the bunk. A similar percentage (83%) reported that performance was “improved” or “very improved” by bunk use. When asked to rate their ability to sleep on the airplane in areas other than the bunk, 27% reported that they were able to sleep “often” or “almost always” in a first class seat, 10% in a cockpit seat, and 6 % in a passenger seat. Conversely, 74% reported ““never” or “seldom” obtaining sleep in passenger seats, 63% in a cockpit seat, and 31% in a first class seat.

Subjects rated 25 factors on how each factor affected sleep in the bunk, using a scale from 1–“interferes” to 5–“promotes” (with a middle rating of 3–“no effect”). The factors most often identified as promoting sleep (i.e., rated 5) were pillows (13% of all "promote" responses), and readiness for sleep (13%), followed by blankets (11%), sheets (10%), and sleep surface (9%). Factors most often rated as interfering with sleep (i.e., rated 1) were random noise (11% of all "interfere" responses), trips to the bathroom (8%), and thoughts (7%). Figure 2 shows mean ratings scaled as described in section 4.1.2 (i.e., interfering factors as negative values and promoting factors as positive). The 112 additional comments from an open-ended “factor” at the end of the list were grouped into 4 categories. Noise was cited as an interfering factor in 51 responses. Sixty-one other comments identified promoting factors: physical comfort (42 responses), wearing ear plugs (10), and a positive mental attitude (9). Several of these were factors identified earlier as promoting home sleep.

Crewmembers rated four additional factors on the extent to which they interfered with bunk sleep, using a scale from 1–“strongly interferes” to 5–“no effect.” Thirst (41% rated it as 1 or 2) was the factor most often rated as interfering, followed by personal worries (33%) and hunger (28%). About two-thirds (67%) rated respiratory factors as having little or no effect (i.e., rated it 4 or 5). When asked to specify other interfering factors, subjects provided 230 general comments, which were grouped into 7 categories, reinforcing that noise (75 responses), bunk discomfort (63), environment (35), and physiological needs (33) interfered with bunk sleep.

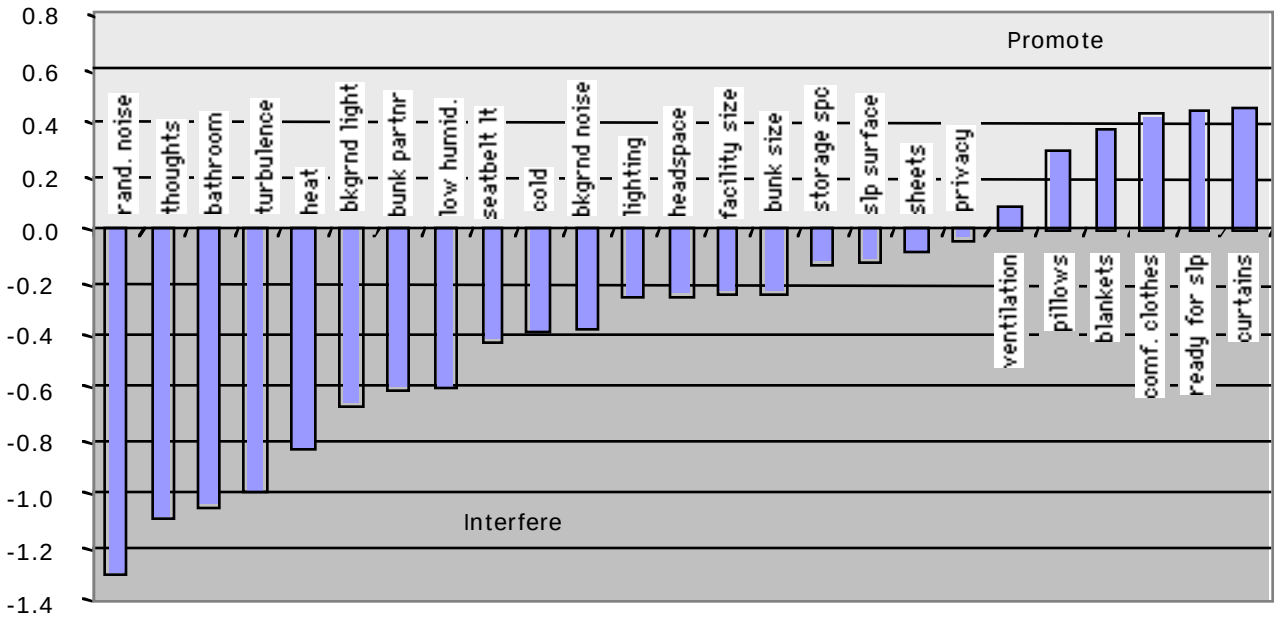


Figure 2. How various factors affected sleep in the bunk (Carrier 1).

An open-ended question on additional factors that promoted bunk sleep yielded 950 responses, which were grouped into 8 categories. Comfort (292 responses or 34%), environment (270, 20%), and fatigue (132, 16%), were most often cited.

Over half of the group (56%) reported using ear plugs to minimize disturbances in the bunk, while a quarter (25%) cited using relaxation techniques. Fewer reported using eye shades (11%) or listening to music (11%). In a comment section, 123 subjects specified reading or changing into comfortable clothes as activities that helped them sleep.

Pre-trip strategies to promote bunk sleep (i.e., actions taken before boarding the aircraft) were described by 553 subjects. Strategies were grouped into 8 categories. The most frequently reported pre-trip strategy (246 responses or 45%) was scheduling sleep at home with regard to the predicted time of the bunk period, thereby maximizing the ability to sleep in the bunk. The next most frequently cited strategy (137 responses or 26%) was to bring comfort aids, such as cotton sheets and pillow cases and soft, loose clothing (e.g., a jogging suit) to enhance physical comfort.

When asked for suggestions on how to make the crew rest facility more conducive to sleep, crewmembers gave 1510 recommendations, which were grouped into 7 categories. Comfort was emphasized by 509 respondents (34%). This category included larger and thicker mattresses, cloth sheets and pillow cases, and bigger pillows and blankets. More soundproofing from random noises was suggested by 409 respondents (27%). Other suggestions included a larger bunk area (135 responses or 10%), more privacy (134, 9%), and better environmental controls (124, 8%).

4.1.4 Comparisons within Carrier 1

Aircraft Type

Data were analyzed for an aircraft-type effect. Tests were conducted to compare responses from crewmembers of B747-100/200 aircraft (n = 498, 69%) with those from crewmembers of B747-400 (n = 229, 31%).

T-tests were used to compare responses from the two groups concerning demographics and home sleep, with only one significant finding. The ’400 group rated themselves better as

home sleepers ($t_{(717)} = 2.35$, $p < .05$) than did the ’100/200 group.

When bunk sleep data were compared, several significant differences were found. The percentage of cruise time ’400 crews reported spending in the bunk (46%) was almost twice that of the ’100/200 crews (26%) ($t_{(364)} = 28.43$, $p < .001$). The two aircraft have different crew requirements (2-person vs. 3-person crew stations on the flight deck), which may result in different rostering, and they may be operated for different flight durations (see sec. 5.1). The ’100/200 group reported greater difficulty sleeping in the bunk ($t_{(708)} = 5.21$, $p < .001$) than did the ’400 group. Consistent with this finding, the ’400 group rated the bunk significantly better overall ($t_{(707)} = 7.58$, $p < .001$). The improvements to alertness and performance reported by ’400 crewmembers were significantly greater than those reported by the ’100/200 group (alertness $t_{(708)} = 6.12$, $p < .001$; performance $t_{(706)} = 5.29$, $p < .001$). On the other hand, the ’100/200 group reported being able to sleep in both cockpit seats ($t_{(498)} = 3.55$, $p < .001$) and first class seats ($t_{(415)} = 4.28$, $p < .001$) more often than the ’400 group .

The influence of specified factors on bunk sleep also were compared for an aircraft-type effect. Factors reported to affect bunk sleep were compared using a two-sample test for equality of proportions. A proportion was calculated by comparing the number of "promote" (or "interfere") responses for a given factor to the total number of "promote" (or "interfere") responses for all 25 factors. In this analysis, a "promote" response refers only to a rating of “5–promotes”; likewise, an "interfere" response refers to a rating of “1–interferes.”

Two promoting factors, “readiness for sleep” and “curtains,” were found to differ significantly between the groups. A significantly higher proportion of ’100/200 pilots (15%) than ’400 pilots (10%) identified readiness for sleep to be a sleep-promoting factor ($\chi^2_{(1)} = 6.33$, $p < .05$). A significantly higher proportion of ’400 pilots (15%) than ’100/200 pilots (5%) reported that curtains promoted sleep ($\chi^2_{(1)} = 46.47$, $p < .001$). Similarly, factors identified as interfering with bunk sleep were compared. Two factors, “trips to bathroom” and “turbulence,” differed significantly between the two groups. A higher proportion of ’400 pilots (11%) than ’100/200 pilots (7%) rated trips to the bathroom as interfering ($\chi^2_{(1)} = 11.79$, $p < .001$). Additionally, a higher proportion of ’400 pilots (9%) than ’100/200 pilots (6%) rated turbulence as interfering ($\chi^2_{(1)} = 9.10$, $p < .01$).

Age

Older crewmembers were compared to their younger counterparts to reveal any age effects. The group was divided into two age brackets, based on an approximate mean split (mean = 44.5): 45 yr. or younger (N = 384), and older than 45 yr (N = 346). The older group reported greater use of medications to help them sleep at home ($t_{(701)} = 2.19$, $p < .05$).

The factors reported to promote sleep in the bunk were compared using a two-sample test for equality of proportions. No significant differences were found. Likewise, factors identified as interfering with sleep were compared. A significantly higher proportion of the older crewmembers (8%) than younger (6%) indicated that heat interfered with bunk sleep ($\chi^2_{(1)} = 5.06$, $p < .05$).
Examination of other bunk sleep variables revealed one significant difference. Improvements in overall alertness were reported to a greater degree by the younger group ($t_{(708)} = 2.69$, $p < .01$) than by the older group.

Good vs. Poor Sleepers

Subjects were classified as “good” or “poor” sleepers based on how they rated themselves as home sleepers (ratings of “good” and “very good” were combined, as were “poor” and “very poor”). A series of t-tests were conducted to compare differences between the two groups.
The groups exhibited several significant differences regarding home sleep. Good sleepers reported a higher average total sleep time (7.9 h.) than poorer sleepers (7.3 h.)

($t_{(72)} = 4.60$, $p < .001$) and fewer daytime naps ($t_{(916)} = 2.15$, $p < .05$). Predictably, good sleepers reported having less trouble getting to sleep ($t_{(714)} = 8.54$, $p < .001$) and using medication less often ($t_{(72)} = 3.56$, $p < .001$) to help them sleep.

Concerning bunk sleep, the good sleepers reported a significantly shorter time to fall asleep (17.8 min.) than did the poor sleepers (34.7 min.) ($t_{(68)} = 4.16$, $p < .001$). Not surprisingly, good sleepers also reported having less difficulty sleeping in the bunk ($t_{(86)} = 6.49$, $p < .001$). They rated their overall attitude toward the bunk significantly higher ($t_{(709)} = 3.39$, $p < .01$) than did the poor sleepers, and they reported greater improvement to both alertness ($t_{(72)} = 2.86$, $p < .01$) and performance ($t_{(74)} = 2.45$, $p < .05$) as a result of bunk sleep.
No significant differences were found between the groups when factors affecting bunk sleep were compared.

4.2 Carrier 2

Crewmembers from Carrier 2 completed and returned 107 surveys of 220 sent (a 49% response rate). Carrier 2 provided a much smaller sample than either of the other carriers because it operated fewer long-haul aircraft equipped with bunks.

4.2.1 Demographics

Carrier 2 responses (see Appendix C) were received from 62 Captains (58%) and 45 First Officers (42%). All of the pilots in this group were flying the MD-11 aircraft. Total flight hours averaged 13,804 h. (range = 400 to 30,000 h.). Their experience flying long-haul operations averaged 7.1 yr., ranging from several months to 32 yr.

All of the subjects in this sample were male. The group averaged 48.2 yr. of age and ranged from 30 to 59 yr. The average weight was about 182 lb. (range = 131–230 lb.), and the average height was 70.8 in. (range = 66–75 in.).

The Central time zone was the most frequently reported home time zone (55%) and the Pacific time zone second most common (34%). A majority (87%) reported having a regular sleeping partner, and about a third (34%) had one or more children younger than 18 living at home.

4.2.2 Sleep at Home

Data on home sleep habits were analyzed for the 107 subjects. The average bedtime was 2258 h. (10:58 p.m.), and the average get-up time was 0715 h. (7:15 a.m.). Subjects reported that it took almost 18 min. to fall asleep (mean = 17.6), and that they usually awakened 1 or 2 times during the night. The 107 responses to an open-ended question on the causes of awakenings were grouped into 5 categories. The main causes reported were physiological needs (72 reports, or 68%) and disturbances from family members or pets (13). After awakening, it took subjects about 12 minutes (mean = 12.2 min.) to go back to sleep. The average total sleep duration was almost 8 hours (mean = 7 h. 50 min.). More than half of the group (51%) reported “never” or “seldom” taking a nap during the daytime. Nearly two-thirds (64%) reported “never” or “seldom” having problems getting to sleep.

Subjects rated 18 factors on how each affected home sleep, using the scale from 1-“interferes” to 5-“promotes” (with the middle rating 3-“no effect”). The factors most often identified as promoting sleep (i.e., rated 5) were comfort aids, such as pillows (15% of all "promote" responses), sleep surface (11%), sheets (9%), and blankets (7%). Proper ventilation (12%) was the second most frequently selected promoting factor, emphasizing the importance of environmental factors. Readiness to sleep, representing the physiological component of the ability to fall asleep, was the third most frequently cited factor and accounted for 11% of "promote" responses. The factors most often cited as interfering with sleep (i.e., rated 1) were heat (20% of all "interfere" responses), thoughts (15%), high humidity (13%), random noise (13%), and trips to the bathroom (11%). Figure 3 shows mean ratings scaled as described in section 4.1.2 (i.e., with interfering

factors as negative values and promoting factors as positive). These findings were supported by the 10 responses to an "other (specify)" comment question ending the list of factors. The comments were grouped into 4 categories, all of which were cited as promoting sleep: environment (5 responses), good mental attitude (3), physical activity (1), and comfort (1).

Respondents rated four specific factors for the degree to which they interfered with sleep at home, using a scale of 1-"strongly interferes" to 5-"no effect." "Personal worries" was cited most as interfering with sleep (with 55% of the pilots rating it 1 or 2 on the scale), followed by thirst (38% rated it 1 or 2), and hunger (23%). Well over half of the subjects (61%) rated respiratory factors as having little or no effect. An open-ended question asked for additional interfering factors. The 14 responses were grouped into 3 categories, with the most common responses being noise (11 responses), pain (2), and mental attitude (1).

An open-ended question asking respondents to list factors that promote home sleep yielded 137 responses, which were grouped into 8 categories. The following factors were most often identified as promoting sleep: physical environment (48 responses—37% of the responses), exercise and physical activities (23, 18%), comfortable sleep area (17, 13%), pre-sleep activities (16, 13%), and good mental attitude (15, 12%).

A majority of the group (87%) reported "never" or "seldom" using medication as a sleep aid. Of the 9 subjects who reported using medication to help them sleep, 7 used cold remedies or aspirin, and 2 used sleeping pills. Most of the group (92%) reported "never" or "seldom" using alcohol to help them sleep.

Ninety-two percent rated themselves as "good" or "very good" sleepers. Most of the group (94%) reported that they had no sleep problem. Those few (7) who reported sleep problems cited being a restless sleeper, or being disturbed by thoughts and worries. Only 2 pilots reported having had their sleep problem diagnosed by a physician, and none reported that the sleep problem had ever prevented them from flying a scheduled trip.

4.2.3 Bunk Sleep (MD-11 aircraft)

In the year preceding the study, each pilot used the crew rest facility in his current aircraft an average of 34 times and used the facilities in other aircraft about 1 or 2 times. Concerning which bunk they usually used, 68% of the subjects reported using the upper bunk, 17% the lower bunk, and 15% reported either bunk.

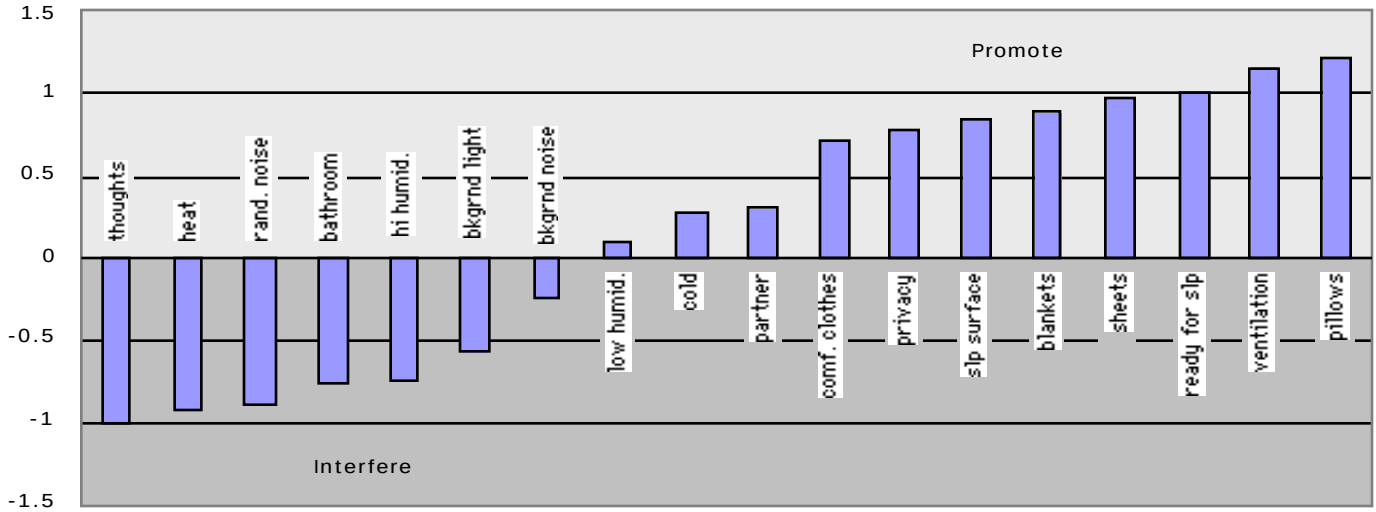


Figure 3. How various factors affected sleep at home (Carrier 2).

A large percentage (85%) reported having the opportunity to undress for a more comfortable sleep, and 60% reported that it was important for them to undress for a comfortable sleep in the bunk. It took crewmembers an average of 27 min. to fall asleep (range = 1 to 120 min.). They typically slept an average of 1 h. 39 min. in the bunk, and typical sleep durations ranged from 20 min. to 3 h. 14 min. Subjects also reported the longest and shortest bunk sleep periods they had experienced. The longest bunk sleeps reported averaged 2 h. 48 min., and the average shortest bunk sleep was 1 h. 4 min. More than a third of the group (35%) reported "never" or "seldom" having difficulty sleeping in the bunk. On the other hand, nearly a third of the group (31%) reported having difficulty sleeping in the bunk "often" or a "majority of time." A quarter (25%) of the group reported using the bunk only for rest and not for sleep "often" or a "majority of time."

Ninety-five percent of the subjects reported that there was no requirement for them to use the bunk. An open-ended question on the factors determining bunk use and rostering received 65 responses, which were grouped into 6 categories. Seniority/crew decision was reported by 35 (54% of responses), identifying it as the principal determinant. Pilots reported, on average, that 38% of cruise time was allocated for each individual to use the bunk.

Asked about their overall attitude toward the bunk, a majority (87%) indicated a "positive" or "very positive" attitude. Almost all of the group (98%) reported that alertness was "improved" or "very improved" by using the bunk. Most (97%) also reported that performance was "improved" or "very improved" by bunk use. When asked to rate their ability to sleep in various locations on the airplane, 83% reported being able to sleep in the bunk "often" or "almost always," 25% in a first class seat, 8% in a cockpit seat, and only 4% in a passenger seat.

Conversely, over three-quarters reported "never" or "seldom" obtaining sleep in a passenger seat (79%) or a cockpit seat (79%), and 39% in a first class seat.

Subjects rated 25 factors on how each affected bunk sleep, using a scale from 1–"interferes" to 5–"promotes" (with a middle rating of 3–"no effect"). The factors most often identified as promoting sleep (i.e., rated 5) were pillows (14% of all "promote" responses), readiness for sleep (10%), blankets (9%), and comfortable clothing (7%). Factors most often rated as interfering with sleep were random noise (20% of all "interfere" responses), bathroom trips (15%), heat (13%), and random thoughts (9%). Figure 4 shows mean ratings scaled as previously described (i.e., with interfering factors as negative values and promoting factors as positive). The 18 additional comments from an open-ended question at the end of the list were grouped into 2 "interfering" categories and the remainder were "promoting" factors. Noise was cited by 11 subjects as an interfering factor, and the downward tilt of the head in the bunk was cited by 4 subjects as interfering. Promoting factors included fast cockpit access, clean linens, and using an alarm.

Pilots rated five additional factors on the extent to which they interfered with bunk sleep, using a scale from 1–"strongly interferes" to 5–"no effect." Thirst (36% rated it as 1 or 2) was the factor most often rated as interfering, followed by personal worries (28%), hunger (22%), and claustrophobia (10%). Almost three-quarters (73%) rated respiratory factors as having little or no effect. Asked to specify other interfering factors, subjects provided 33 general comments grouped into 6 categories, reinforcing that noise (17 responses) and environment (4) interfered with bunk sleep. Five subjects identified smoke from the flight attendants as interfering as well.

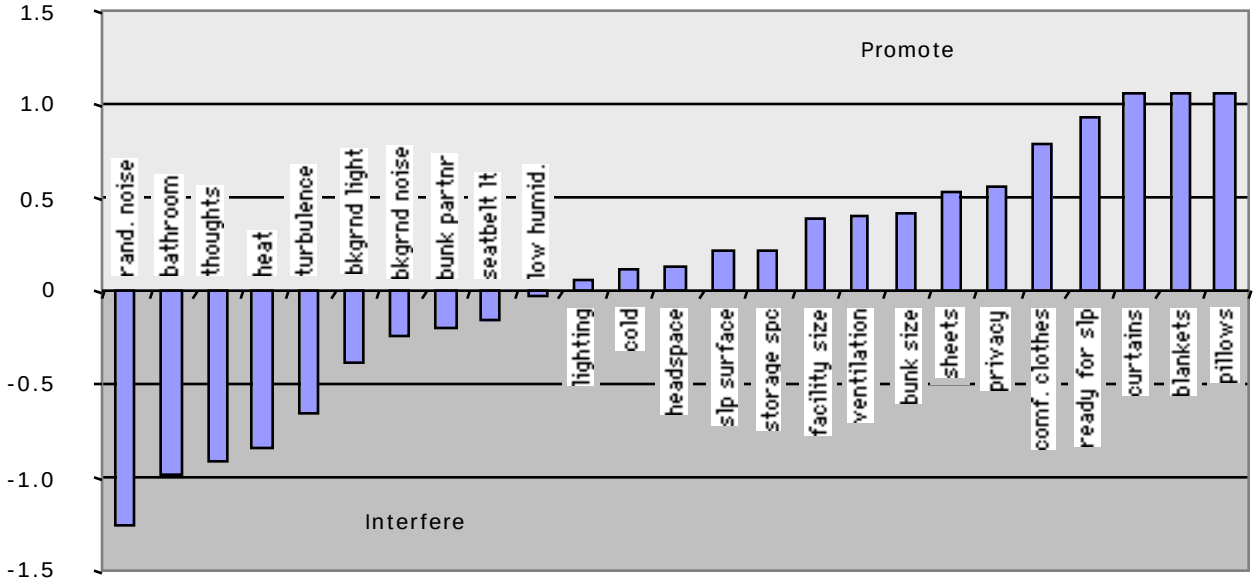


Figure 4. How various factors affected sleep in the bunk (Carrier2).

_An open-ended question on additional factors that promoted bunk sleep yielded 104 comments, which were grouped into 8 categories. Quiet (25 responses), comfort (15), and environment (14) were most frequently cited.

A quarter of the group (24%) reported using relaxation techniques to facilitate sleep in the bunk, and only 20% of the group cited using ear plugs . Very few reported listening to music (6%) or using eye shades (3%). Additionally, six identified reading as an activity that helped them sleep.

Pre-trip strategies to promote bunk sleep (i.e., actions taken before boarding the aircraft) were described by 46 subjects and were grouped into 7 categories. The most frequently reported pre-trip strategy (10 responses) was scheduling sleep at home with regard to the predicted time of the bunk period, thereby maximizing the ability to sleep during the bunk period. The next most frequently cited strategies were to limit food intake (7), to avoid caffeine (5), to exercise (5) and to limit food (4) and fluid (4) intake.

When asked for suggestions on how to make the crew rest facility more conducive to sleep, crewmembers gave 142 recommendations, which were grouped into 7 categories. Locating the bunk away from the galley was the most common, cited by 36 respondents. Another 25 proposed enhancing personal comfort by providing larger and thicker mattresses, cloth sheets and pillow cases, and larger pillows and blankets. Improving environmental controls (i.e., for ventilation, humidity, and temperature) was suggested by 21 others. Soundproofing from random noises was suggested in 15 responses.

4.2.4 Comparisons within Carrier 2

Aircraft Type

All subjects from Carrier 2 operated MD-11 aircraft, which precluded aircraft-type comparisons for this data set.

Age

The data set was divided into 2 groups according to age using the same criterion as for Carrier 1, that is, 45 yr. and younger (N = 44) vs. older than 45 (N = 63). When the home sleep data from the two age groups were

compared, only one significant difference was found. With regard to the usage of alcohol as a sleep aid at home, the younger group reported a slightly higher ($F_{(1, 105)} = 4.03$, $p < .05$) degree of usage than did the older group. However, the average response from each group corresponded to “never” or “seldom” using alcohol as a sleep aid (i.e., 0–4 times/yr.).

When bunk sleep factors were compared for age effect, only one significant difference was found. The older group identified turbulence as a factor that interfered with sleep significantly more frequently ($t_{(101)} = 2.88$, $p < .05$) than the younger group (none of the younger group rated it as an interfering factor). Comparison of promoting factors revealed no significant differences between the groups.

Good vs. Poor Sleepers

Carrier 2 subjects were categorized as “good” sleepers or “poor” sleepers based on the criteria used for Carrier 1 (see sec. 4.1.4). However, because only 8 subjects (7%) in this group rated themselves as poor sleepers, statistical comparison was deemed inappropriate.

4.3 Carrier 3

Crewmembers from Carrier 3 completed and returned 560 surveys of 1500 sent (a 37% response rate).

4.3.1 Demographics

Carrier 3 responses (see Appendix D) were received from 171 Captains (32%), 295 First Officers (55%), 68 Second Officers (13%), and 4 International Relief Pilots (< 1%). Slightly under half of this group (47%) were flying the B747-100/200 series, while slightly over half (53%) were flying the B747-400. Total flight hours averaged 15,012 h., ranging from 400 to 38,000 h. Crewmembers’ experience flying long-haul operations averaged 8.6 years, and ranged from ten months to 40 years.
The sample consisted of 541 males (98%) and 9 females. The average age was 51.2 yr., and ranged from 26 to 73 yr. Sixty-two crewmembers (11%) between the ages of 60 and 73 responded to the survey. The average weight was 184 lb. (range = 105 to 280 lb.). The average height was 70.7 in. (range = 62 to 81 in.).

The Pacific time zone was the most frequently reported home time zone (44%), the Eastern time zone second most common (22%), and the Mountain time zone third (21%). A majority of subjects (88%) reported having a regular sleeping partner, and over a third (36%) had children under the age of 18 living at home.

4.3.2 Sleep at Home

Data on home sleep habits were analyzed for the 560 subjects. The average bedtime was 2301 h. (11:01 p.m.), and the average get-up time was 0721 h. (7:21 a.m.). Crewmembers reported that it took about 20 minutes to fall asleep (mean = 20.5 min.) and that they usually awakened 1 to 2 times during the night. The 522 responses to an open-ended question on the causes of awakenings were grouped into 6 categories. The most frequently reported causes were physiological needs (312 responses, or 59%), inability to sleep (87, 17%), noise (51, 10%), and disturbances from family members or pets (48, 9%). After awakening, it took subjects about 15 minutes (mean = 15.2 min.) to go back to sleep. The average total sleep duration was almost 8 hours (mean = 7 h. 50 min.). Half of the group (50%) reported “never” or “seldom” taking a nap in the daytime. Over half (59%) reported “never” or “seldom” having problems getting to sleep.

Respondents rated 18 factors on how each affected home sleep, using a scale from 1–“interferes” to 5–“promotes” (with a middle rating of 3–“no effect”). The factors most often identified as promoting sleep (i.e., rated 5) were comfort aids such as pillows (14% of all "promote" responses) and sleep surface (14%). Readiness for sleep, representing the physiological component of the ability to fall asleep, was the third most frequently cited factor and accounted for 13% of "promote" responses. Proper ventilation

was also emphasized (11%). The factors most often cited as interfering with sleep were random thoughts (18% of all "interfere" responses), heat (14%) and random noise (12%). Figure 5 shows mean ratings scaled as described in section 4.1.2 (i.e., with interfering factors as negative values and promoting factors as positive). These findings were supported by responses to an “other (specify)” comment question ending the list. All 60 of the responses were cited as promoting sleep. The comments were grouped into 4 categories: environment (26 responses), good mental attitude (15), physical activity (12), and comfort (7).

Respondents rated four additional factors for the degree to which they interfered with sleep at home, using a scale of 1-“strongly interferes” to 5-“no effect.” “Personal worries” was cited most as interfering with sleep (63% of the crewmembers rated it 1 or 2), followed by thirst (49%), and hunger (33%). More than half (53%) rated respiratory factors as having little or no effect. An open-ended question asked for additional interfering factors. The 41 responses were grouped into 5 categories, the most common being noise (23 responses) and poor mental attitude (9).

An open-ended question asking respondents to list factors that promote their home sleep yielded 872 responses, which were grouped into 9 categories. The following factors were most often identified as promoting sleep: good physical environment (379 responses, or 43%), comfort (144, 17%), and good mental attitude (128, 15%).

Most of the group (99%) reported “never” or “seldom” using medications as a sleep aid. Of the 92 subjects who reported using medication to help them sleep, 62 used cold remedies or aspirin, and 25 used sleeping pills. A majority of the group (86%) reported “never” or “seldom” using alcohol to help them sleep.

About 90% rated themselves as “good” or “very good” sleepers. A majority of the group (86%) reported that they had no sleep problem. The 84 subjects who reported sleep problems cited being a restless sleeper (26 responses) or circadian disruption (17). Only 12 respondents reported having had the problem diagnosed by a physician, and 15 reported that the problem had prevented them from flying a scheduled trip.

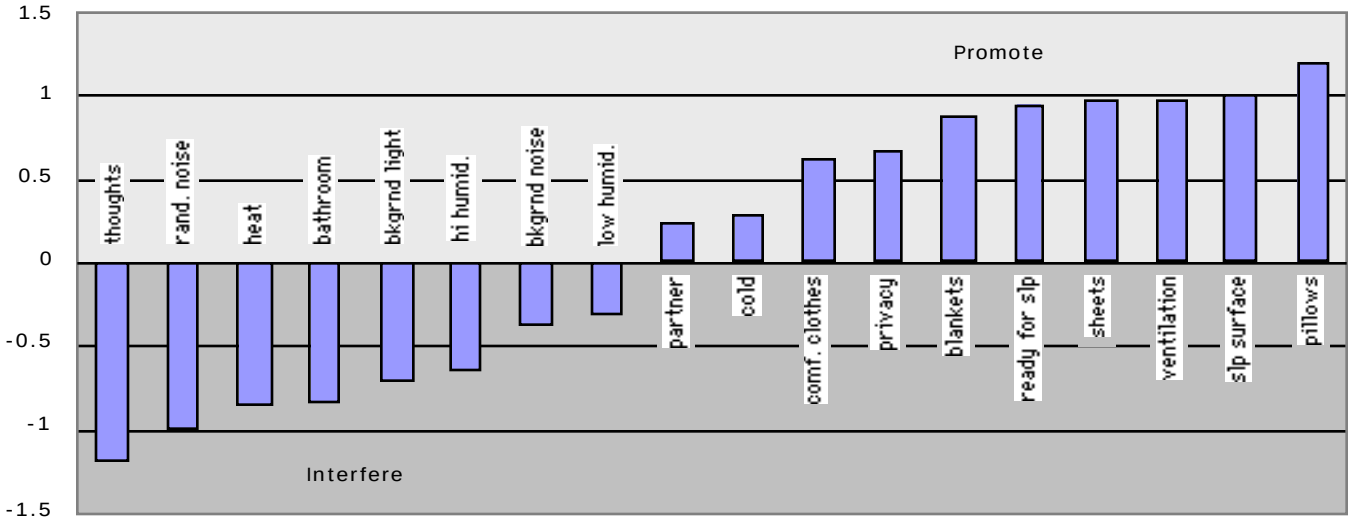


Figure 5. How various factors affected sleep at home (Carrier 3).

4.3.3 Bunk Sleep (B747-100/200 and B747-400)

In the year preceding the study, each subject used the crew rest facility in his or her current aircraft an average of 26 times and used the facilities in other aircraft about 2 times. Concerning which bunk they usually used, 17% of the subjects reported using the upper bunk, 49% the lower bunk, and 34% reported either bunk.

A large percentage (71%) reported having the opportunity to undress for a more comfortable sleep, and 74% reported that it was important for them to undress for a comfortable sleep in the bunk. It took crewmembers an average of 42 min. to fall asleep (range = 1–300 min.). They typically slept an average of 2 h. 22 min. in the bunk, and typical sleep durations ranged from 10 min. to 7 h. Subjects also reported the longest and shortest bunk sleep periods they had experienced. The longest bunk sleeps reported averaged 3 h. 39 min., and the shortest bunk sleeps averaged 1 h. 15 min. Nearly half of the group (49%) reported having difficulty sleeping in the bunk "often" or a "majority of time," while a fifth (20%) reporting having difficulty "never" or "seldom." Additionally, more than a quarter of the group (27%) reported using the bunk for rest only (i.e., not sleep) "often" or a "majority of time."

Ninety-three percent of the crewmembers reported that there were no requirements for them to use the bunk. An open-ended question on the factors determining bunk use and rostering received 384 responses, which were grouped into 6 categories. Seniority/crew decision was reported by 162 (43%), identifying it as the principal determinant. Length of flight was cited by 87 subjects (23%) and augmentation by 70 (18%). Subjects reported, on average, that 34% of cruise time was allocated for each individual to use the bunk.

When asked about their overall attitude about the bunk, nearly three quarters of the group (73%) indicated a "positive" or "very positive" attitude. Most (91%) reported that alertness was "improved" or "very improved" by using the bunk. A similar percentage (90%) reported that performance was "improved" or "very improved" by bunk use. When asked to rate their ability to sleep in various locations on the airplane, 72% reported being able to sleep in the bunk "often" or a "majority of time," 32% in a first class seat, 10% in a passenger seat, and 8% in a cockpit seat. Conversely, high percentages of respondents reported "never" or "seldom" obtaining sleep in cockpit seats (71%) and in passenger seats (67%).

Subjects rated 25 factors on how each affected bunk sleep, using a scale from 1–"interferes" to 5–"promotes" (with a middle rating of 3–"no effect"). The factors most often identified as promoting sleep (i.e., rated 5) were comfort aids, such as pillows (13% of all "promote" responses), curtains (11%), and blankets (10%). Readiness for sleep, representing the physiological component of the ability to fall asleep, was third most frequently cited and accounted for 11% of "promote" responses. Factors most often rated as interfering with sleep were random noise (13% of all "interfere" responses), turbulence (10%), and trips to the bathroom (9%). Figure 6 shows mean ratings scaled as described in section 4.1.2 (i.e., with interfering factors as negative values and promoting factors as positive). The 59 additional comments from an open-ended question at the end of the list were grouped into 4 categories. Noise was cited by 24 subjects as an interfering factor. Other comments identified promoting factors, including physical comfort (25 responses) and good mental attitude (4).

Crewmembers rated five additional factors on the extent to which they interfered with bunk sleep, using a scale from 1–"strongly interferes" to 5–"no effect." Thirst (43% rated it as 1 or 2) was the factor most often rated as interfering, followed by personal worries (41%), hunger (33%), and claustrophobia (8%). More than half (61%) rated respiratory factors as having little or no effect. Asked to specify other interfering factors, subjects gave 119 comments, which

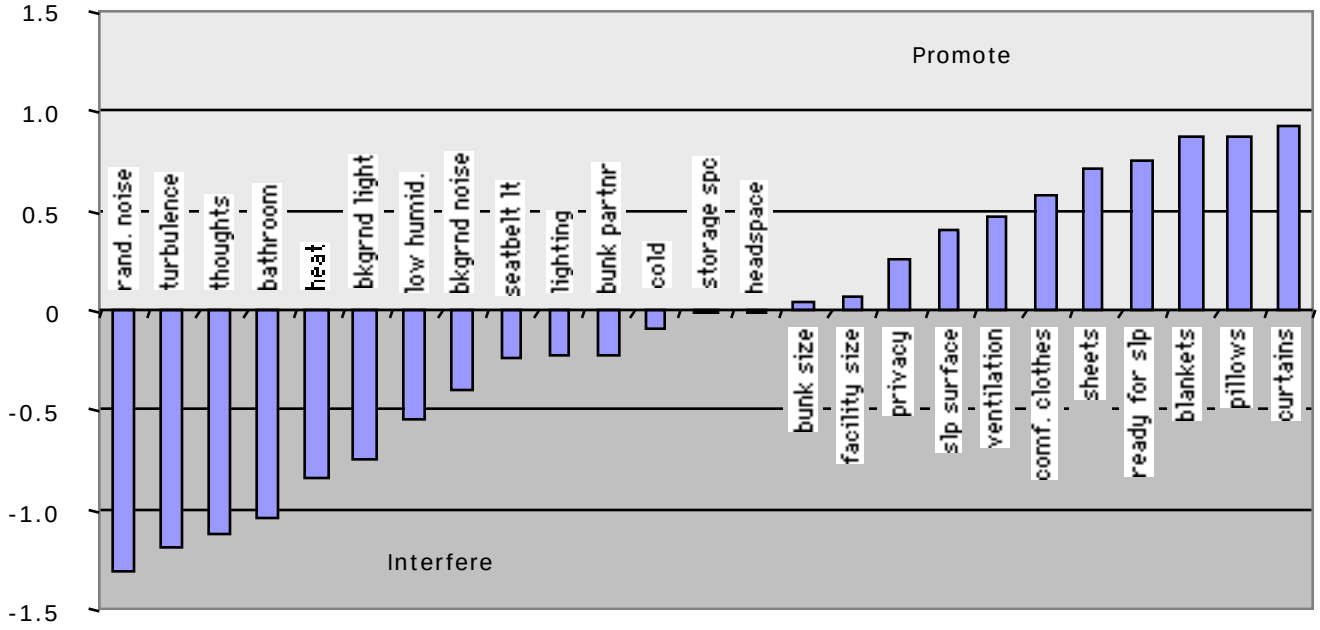


Figure 6. How various factors affected sleep in the bunk (Carrier 3).

were grouped into 6 categories, reinforcing that noise (40) and physiological needs (21 responses) interfered with bunk sleep.

An open-ended question on additional factors that promoted bunk sleep yielded 671 responses, which were grouped into 8 categories. Environment (342 responses, or 46%) and comfort (206 or 27%) were most frequently cited.

Nearly a third of the group (32%) reported wearing ear plugs to minimize disturbances in the bunk, and 31% reported using relaxation techniques. Some listened to music (18%) or wore eye shades (12%). In a comment section, subjects identified reading (61 responses) or changing into comfortable clothes (23) as activities that helped them sleep.

Pre-trip strategies to promote bunk sleep (i.e., actions taken before boarding the aircraft) were described by 433 subjects and were grouped into 8 categories. The most frequently reported pre-trip strategy (219 responses, or 50%) was scheduling sleep at home with regard to the predicted time of the bunk period, thereby maximizing the ability to sleep during the bunk period. The next most frequently cited strategy was to avoid caffeine (56 responses, or 13%).

When asked for suggestions on how to make the crew rest facility more conducive to sleep, subjects gave 896 recommendations, which were grouped into 7 categories. Comfort was emphasized by 312 respondents (35%), including larger and thicker mattresses, cloth sheets and pillow cases, and bigger pillows and blankets. Soundproofing from random noises was suggested by 187 respondents (21%). Other suggestions included a larger bunk area (93 responses, or 11%), more privacy (87, 10%), and better environmental controls (78, 9%).

4.3.4 Comparisons within Carrier 3

Aircraft Type

Data from Carrier 3 were analyzed for an aircraft-type effect in the same manner as for Carrier 1. Tests were run to compare responses from crewmembers of B747-100/200 aircraft (N= 257 or 47%) with those from crewmembers of B747-400's (N= 291 or 53%).

When demographic and home sleep data were compared for significant differences, the ’100/200 group was found to be significantly older and more experienced. On average, the ’100/200 group (mean age = 53.0 yr.) was 3.4 years older than the ’400 group (49.6 yr.) ($F_{(1, 546)} = 23.35$, $p < .001$), reported nearly 3,000 more total flight hours ($F_{(1, 535)} = 23.85$, $p < .001$), and had 4 yr. more experience flying long-haul operations ($F_{(1, 443)} = 23.19$, $p < .001$).

Comparison of bunk sleep data also revealed several differences. The ’100/200 group reported an average sleep latency of approximately 38 min., which was about seven minutes less than the average reported by the ’400 group ($F_{(1, 474)} = 5.52$, $p < .05$). The average duration of bunk sleep periods differed dramatically between the two groups ($F_{(1, 483)} = 321.63$, $p < .001$), with the ’400 group reporting nearly twice as much sleep (3.1 h.) on average than the ’100/200 group (1.4 h.). The two aircraft have different crew requirements (2-person vs. 3-person crews), which may result in different rostering, and they may be operated for different flight durations.

The groups’ overall ratings of the bunk facility differed significantly ($F_{(1, 405)} = 112.07$, $p < .001$), with the ’400 receiving superior ratings. The ratings by ’400 crewmembers corresponded to an assessment between “positive” and “very positive,” while the assessment by ’100/200 crews was closer to “neutral.” Further, when rating how bunk sleep affected alertness ($F_{(1, 533)} = 31.66$, $p < .001$) and performance ($F_{(1, 531)} = 36.31$, $p < .001$), ’400 crewmembers indicated more improvement than did the ’100/200 crews.

The influence of specified factors on bunk sleep also were compared for an aircraft-type effect. The degree to which factors interfered with bunk sleep were compared using a 2-sample test for equality of proportions. Responses from the two aircraft groups differed concerning several factors. A higher proportion of the ’400 group identified heat ($\chi^2_{(1)} = 5.20$, $p < .05$), random thoughts ($\chi^2_{(1)} = 3.96$, $p < .05$), bathroom trips ($\chi^2_{(1)} = 40.08$, $p < .001$), and turbulence ($p < .001$) as interfering factors than the ’100/200 group. The proportion of the ’100/200 group (14%) citing random noise as an interfering factor was higher ($\chi^2_{(1)} = 4.04$, $p < .05$) than that of the ’400 group (11%). The two aircraft groups showed more consistency in identifying factors that promoted bunk sleep, though a higher proportion of ’400 group (10%) reported sheets as promoting sleep ($\chi^2_{(1)} = 4.99$, $p < .05$) than that of the ’100/200 group (7%).

Age

The data set was divided into 2 groups according to age using the same criterion as for Carrier 1 (i.e., 45 yr. and younger vs. older than 45). Because this group was slightly older than the others, the age 45 break led to unequal group sizes (N= 138 for the younger group, and N= 405 for the older).
The two age groups reported different get-up times at home ($F_{(1, 541)} = 5.99$, $p < .05$), with the younger group waking up about 15 minutes later than the older group. Consistent with this finding, the younger group’s typical sleep duration was about 14 minutes longer than that of the older group ($F_{(1, 542)} = 9.08$, $p < .01$). The groups reported falling asleep at similar times.

The other significant difference in the home sleep data concerns the use of alcohol as a sleep aid. The younger group reported using alcohol as a sleep aid slightly more frequently ($F_{(1, 206)} = 5.61$, $p < .05$) than the older group. However, the average response from each group corresponded to “never” or “seldom” using alcohol as a sleep aid (i.e., 0 to 4 times/yr.).

When bunk sleep factors were compared for age effect, only one significant difference was found. The younger group identified “comfort of clothing” as a promoting factor more frequently ($\chi^2_{(1)} = 11.59$, $p < .001$) than did the older group. No significant differences were found in factors that interfered with sleep.

Good vs. Poor Sleepers

Carrier 3 subjects were categorized as "good" sleepers or "poor" sleepers by the criteria used for Carrier 1. About 90% of the subjects were classified as good sleepers, and the poor sleep group comprised only 10% .

Demographically, no significant differences were found between the two groups. When home sleep data were compared, sleep latency and total sleep duration were found to differ significantly. The poor sleep group reported an average sleep latency of about 34 min., which is more than 15 min. longer than average latency reported by the good sleep group ($F_{(1, 61)} = 5.61$, $p < .01$). Consistent with this finding, the poor sleepers reported sleep durations that averaged 36 min. shorter than those of the good sleepers ($F_{(1, 62)} = 19.30$, $p < .001$). Not surprisingly, the poor sleepers also reported having more difficulty getting to sleep than the good sleepers ($F_{(1, 543)} = 65.48$, $p < .001$). The poor sleep group's average rating corresponded to "sometimes" (1–3 times/mo.) having problems getting to sleep, while the good sleep group's average rating corresponded to "seldom" (1–4 times/yr.) having problems. The poor sleepers also reported using medication more often ($F_{(1, 59)} = 19.41$, $p < .001$) to help them sleep.

Consistent with the home sleep differences, the poor sleep group reported an average bunk sleep latency of 52.5 min., which was 12 min. longer than that of the good sleep group ($F_{(1, 505)} = 6.65$, $p < .01$). Further, the typical duration of bunk sleep reported by the poor sleepers (mean = 1.9 h.) was about 30 min. less ($F_{(1, 517)} = 5.82$, $p < .05$) than that of the good sleepers (mean = 2.4 h.).
No differences were found between the two groups concerning overall attitude toward the bunk or the effects of bunk sleep on alertness and performance.

4.4 Comparisons Across All Three Carriers

4.4.1 Demographics

Demographic data were compared among the three carriers using one-way analysis of variance (see table 1). A significant difference was found in the number of flight hours ($F_{2, 1360} = 24.17$, $p < .001$), with Carrier 3 reporting the most (mean = 15,012 h.) and Carrier 1 the least (mean = 12,436 h.). A Tukey post hoc comparison test revealed that the difference between Carriers 1 and 3 was significant ($p < .01$).

The three groups differed significantly in age as well ($F_{2, 1384} = 104.03$, $p < .001$). Consistent with the differences in flight hours, Carrier 3 was the oldest group (average age 51.2 yr.), and Carrier 1 the youngest (average 44.5 yr.). Post hoc Tukey tests showed significant age differences ($p < .01$) among all three carriers.

Table 1. Demographic differences among the three carriers.

	Carrier 1 (n= 737) mean (SD)	Carrier 2 (n= 107) mean (SD)	Carrier 3 (n= 560) mean (SD)	F	p
Flight Hours	12436 (6219)	13282 (7017)	15012 (6796)	24.17 (2,1360)	**<.001 *****
Years Exper.	8.8 (7.2)	7.1 (7.6)	8.6 (9.4)	2.36 (2,1384)	.09
Age	44.5 (8.2)	48.0 (9.8)	51.2 (8.3)	104.03 (2,1384)	**<.001 *****
Height (in)	71.3 (2.5)	70.8 (2.1)	70.7 (2.7)	8.77 (2,1381)	**<.001 *****
Weight (lb)	183.6 (23.5)	181.7 (21.4)	184.1 (24.5)	0.47 (2,1381)	.63
Body Mass Index	25.4 (2.9)	25.5 (2.6)	25.9 (2.8)	4.44 (2,1334)	**<.05 ***
Kids at Home	0.7 (0.9)	0.4 (0.8)	0.4 (0.7)	22.80 (2,302)	**<.001 *****

The groups differed significantly in height ($F_{2,1381} = 8.77$, $p < .001$) and in body mass index[2] (BMI) ($F_{2,1334} = 4.44$, $p < .05$). Carrier 1, the youngest group, was also the tallest and had the lowest average BMI, while Carrier 3, the oldest group, had the lowest average height and the highest average BMI. Post hoc Tukey tests for height ($p < .01$) and BMI ($p < .05$) showed that the differences between Carriers 1 and 3 were significant.

Body mass index was computed for the 1337 subjects who provided the necessary data. The average BMI was 25.6 kg/m^2. An acceptable BMI falls between 20 and 25 kg/m^2. The BMI's for 41% of the sample were in this range. A small number (2%) were on the "light" end of the scale (i.e., below 20), while about half (50%) were in the "overweight" range, with BMI's between 25 and 30. A BMI of 30 or greater indicates "obesity", and 7% of the subjects fell into this range.

These data were analyzed to examine any correlation between body mass index and a subject's ability to sleep at home (e.g., "good," "poor,"). BMI and type of sleeper did not correlate significantly. A one-way analysis of variance compared the BMI for each of the sleeper categories (i.e., "poor," "fair," "good," "very good"). While the BMI was highest in the small group of "poor" sleepers, the difference was not statistically significant. Further, each BMI range had a high percentage of "good" and "very good" sleepers. About 90% of subjects within the acceptable BMI range (i.e., 20–25) rated themselves as "good" or "very good" sleepers. A similar proportion (91%) of subjects in the "overweight" BMI range of 25–30 rated themselves as "good" or "very good" sleepers. Even in the "obese" group (i.e., BMI over 30), most (86%) rated themselves as "good" or "very good" sleepers.

Carrier 1 also reported a significantly higher number of children under the age of 18 living at home ($F_{2,302} = 22.80$, $p < .001$). While the group averages were all quite low (each group averages less than one child), the average for Carrier 1 was nearly twice that for either of the other two. A post hoc Tukey ($p < .01$) showed this difference to be significant. The average age of Carrier 1 (44.5 yr.) most likely accounts for the higher number of children at home.

4.4.2 Sleep at Home

Home sleep data from the three carriers were compared using one-way analysis of variance (see table 2). There were no significant differences among the carrier groups for these questions.

The data regarding factors that affected home sleep were analyzed as well. Because the three groups did not differ significantly in their responses to questions on home sleep, the data were combined into one set, which was subjected to a principal components analysis.

The ten factors that were found to promote home sleep were analyzed together. The following three principal components accounted for nearly 59% of the total variance:

1) Sleep microenvironment (e.g., sheets, blankets, pillows; 37.5% of variance)
2) Sleep preparedness (e.g., comfort of clothing, ready for sleep; 11.2%)
3) Sleep macroenvironment (e.g., cold, sleep surface; 10.0%)

Likewise, the seven factors that were found to interfere with home sleep were analyzed. Again, three principal components accounted for about 57% of the total variance, which were:

[2] BMI = weight / height^2 (kg/m^2)

Table 2. Differences in home sleep among the three carriers.

	Carrier 1 (n= 737) mean (SD)	Carrier 2 (n= 107) mean (SD)	Carrier 3 (n= 560) mean (SD)	F	p
Asleep (local time)	2258 (0:49)	2256 (0:58)	2301 (0:56)	0.60 (2,1379)	.55
Get Up (local time)	0719 (1:01)	0709 (1:15)	0718 (1:05)	1.08 (2,1384)	.34
Latency (min)	19.4 (27.5)	17.6 (13.9)	20.5 (17.7)	1.09 (2,1382)	.34
Sleep Duration (hr)	7:52 (0:50)	7:50 (0:47)	7:49 (0:53)	0.35 (2,1376)	.70

1) Environmental disturbances (e.g., background noise, lighting, random noise; 26.0%)
2) Personal disturbances (e.g., trips to the bathroom, thoughts; 16.0%)
3) Environmental discomfort (e.g., high humidity, heat; 15.0%)

4.4.3 Bunk Sleep

The ratings for factors that affect bunk sleep by all groups together are shown in figure 7. Figure 8 shows the ratings grouped by type of aircraft flown.

Bunk sleep factors were analyzed for principal components as well. Analysis of the 11 factors found to promote bunk sleep revealed that the following three principal components accounted for about 71% of the total variance:

1) Sleep microenvironment (e.g., blankets, pillow, sheets; 49.0%)
2) Sleep macroenvironment (e.g., facility size, bunk size, ventilation; 11.5%)
3) Sleep preparedness (e.g., ready for sleep, comfort of clothing; 10.0%)

Likewise, the 12 factors identified as interfering with sleep were analyzed, and the following five principal components accounted for about 56% of the total variance:

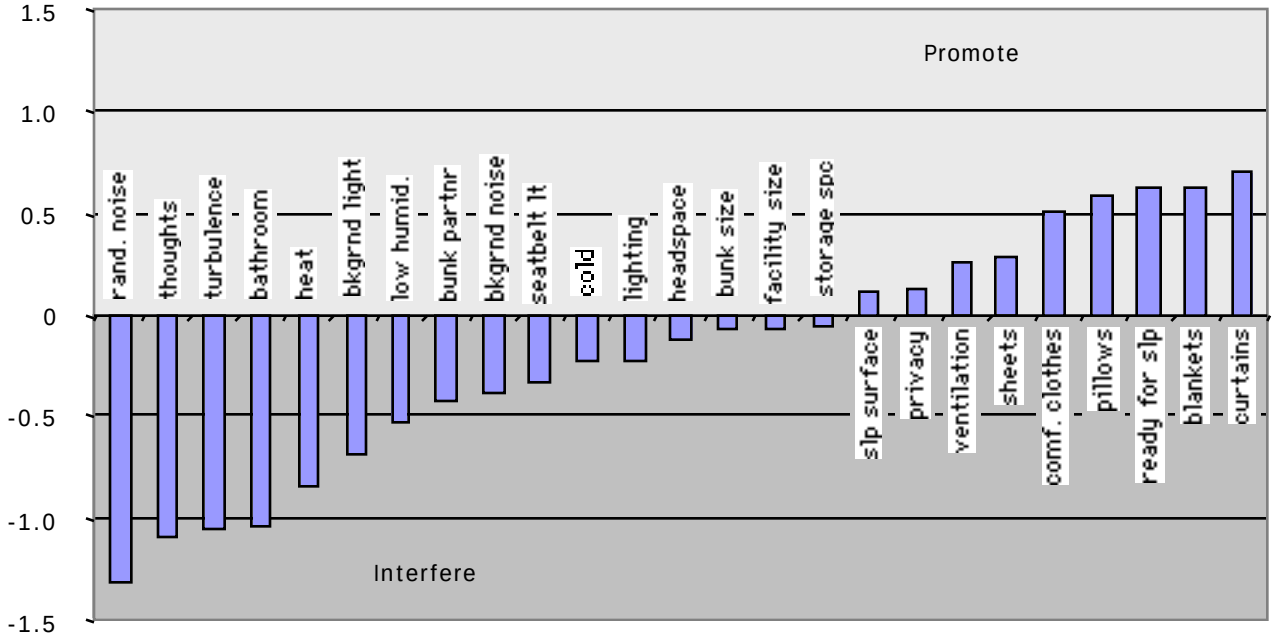


Figure 7. Ratings of bunk factors by all subjects as a group.

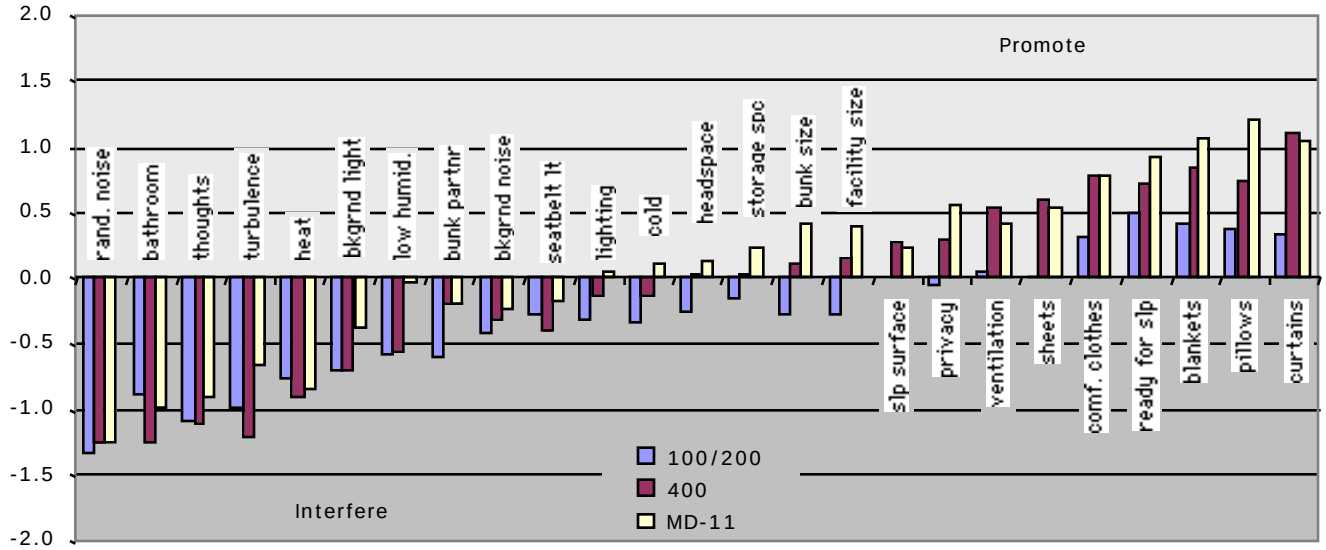


Figure 8. Ratings of factors that affect bunk sleep grouped by type of aircraft flown.

1) Luminosity (e.g., lighting, illuminated seat belt sign; 17.4%)
2) Environmental disturbances (e.g., background noise, turbulence, random noise; 11.2%)
3) Personal disturbances (e.g., trips to the bathroom, thoughts; 9.8%)
4) Environmental discomfort (e.g., low humidity, cold; 8.7%)
5) Sleep macroenvironment (e.g., bunk partner, heat; 8.5%)

The remaining data regarding bunk sleep issues were compared across carriers using one-way analysis of variance (see table 3).

Reports of bunk sleep latency were found to differ significantly ($F_{2,299} = 21.32$, $p < .001$) among the three carriers[3]. The average latency reported by Carrier 2 (26.6 min.) was shorter than each of the other two, Carrier 1 (41.4 min.) and Carrier 3 (39.2 min.). Post hoc Tukey tests showed these differences to be significant ($p < .01$). Different carriers may operate different trip patterns, resulting in bunk periods at different times of day. Circadian factors make it easier to fall asleep at certain times of the day and more difficult at others.

Bunk sleep durations reported by Carriers 2 and 3 were compared (the survey of Carrier 1 did not include this question). The duration reported by Carrier 3 (mean = 2.4 h.) was significantly longer ($F_{1,250} = 53.37$, $p < .001$) than that of Carrier 2 (mean = 1.7 h.). Carrier 3 may have operated longer flights, and the two carriers may have had different rostering practices.

To facilitate analysis of variance, multiple-choice responses with word-based scales were converted into a numerical code. Answers were coded from 1 to 5, in order of the responses as they appeared in the survey (see Appendix 1). Lower values indicated "negative" or "less frequent" responses, and higher values corresponded to "positive" or "more frequent" responses.

Reports of difficulty sleeping in the bunk differed significantly among the groups ($F_{2,1359} = 16.32$, $p < .001$). Post hoc Tukey comparisons revealed that Carrier 2 reported significantly fewer problems ($p < .01$) than either of the other two carriers. The average

[3] Outliers were removed from this data set according to the following criteria: if a subject reported a sleep latency of over 2 hours without reporting any total sleep time, the latency value was not included in the analysis. Such a subject was identified as one who does not sleep in the bunk, and the sleep latency measure was considered inapplicable.

Table 3. Comparison of crewmember bunk sleep by carrier.

	Carrier 1 (n= 737) mean (SD)	Carrier 2 (n= 107) mean (SD)	Carrier 3 (n= 560) mean (SD)	F	p
Latency (min)	41.4 (28.6)	26.6 (19.5)	39.2 (28.6)	21.32 (2,299)	**<.001 *****
Sleep Duration (hr)	no data	1:39 (0:43)	2:22 (1:23)	53.4 (1,1250)	**<.001 *****

group response for Carrier 2 (3.0) signified that the group "sometimes" had difficulty sleeping, while the higher averages for carriers 1 (3.6) and 3 (3.5) indicated a frequency between "sometimes" and "often."

There was a significant group effect ($F_{2,322}$ = 107.63, $p < .001$) regarding overall attitude about the bunk. Post hoc Tukey tests showed that each of the carriers differed significantly ($p < .01$) from the other two. On a 5-point scale from "very negative" through "neutral" to "very positive," Carrier 2 gave the most favorable rating, with an average response (4.5) in the "positive" to "very positive" range; Carrier 3 reported an intermediate rating, with an average response (3.9) just below the "positive" rating; and Carrier 1 gave the lowest rating of the three, with an average response (3.3) near the "neutral" rating point.

Reports of how bunk sleep affected overall alertness also displayed a significant group effect ($F_{2,311}$ = 35.35, $p < .001$). Post hoc Tukey tests showed that all three carriers differed significantly ($p < .01$) from one another. Carrier 2 reported the highest rating (mean = 4.5) indicating an effect midway between "improved" and "very improved"; the average rating from Carrier 3 (4.2) was intermediate; and the rating from Carrier 1 (4.0) indicated "improved".

Finally, there was a significant group effect ($F_{2,1359}$ = 27.46, $p < .001$) regarding how bunk sleep affected overall performance. Post hoc Tukey tests revealed that all three carriers differed significantly ($p < .01$) from one another. Carrier 2 reported the highest rating (mean = 4.4), signifying an effect between "improved" and "very improved," while the average responses for Carriers 3 (3.9) and 1 (4.1), were near the "improved" rating.

4.4.4 Aircraft Type Comparisons

Combined data from all surveys were analyzed with respect to aircraft type. Each subject operated one of three aircraft types: B747-100/200, B747-400, or MD-11. The sample represented 756 B747-100/200 crewmembers (55%), 519 pilots of the B747-400 (38%), and 108 MD-11 crewmembers (8%). All of the MD-11 crews were from Carrier 2, and all crews of the B747 series ('100/200 and '400) were from either Carrier 1 or 3.

One-way analyses of variance were conducted to reveal differences between the aircraft bunks (see table 4). There was a significant difference ($F_{2,344}$ = 29.16, $p < .001$) regarding bunk sleep latency. Post hoc Tukey comparisons showed that the average bunk latency reported by the MD-11 group (25.8 min.) was significantly shorter ($p < .01$) than the latencies for both the '100/200 group (42.2 min.) and the '400 group (44.2 min.). Maximum values of 4 and 5 h., respectively, were reported by the '100/200 and '400 groups, while the maximum latency reported by the MD-11 group was only 2 h. Even with these extreme values removed from the analysis set, the statistical result was significant.

Table 4. Comparison of crewmember bunk sleep by aircraft.

	B747-100/200 mean (SD)	B747-400 mean (SD)	MD-11 mean (SD)	F	p
Latency (min)	42.2 (33.4)	44.2 (39.0)	25.9 (20.0)	29.2 (2,344)	**<.001 *****
Sleep Duration (hr)	1:26 (0:50)	3:07 (1:16)	1:39 (0:43)	167.04 (2,301)	**<.001 *****

Total bunk sleep duration was analyzed for Carriers 2 and 3 (the survey of Carrier 1 did not include this question). The subjects in this analysis were 225 crewmembers of B747-100/200's, 270 of B747-400's, and 96 of MD-11's. A significant between-groups effect ($F_{2,301} = 167.04$, $p < .001$) was revealed. Post hoc Tukey tests showed that the '400 group reported a significantly longer ($p < .01$) bunk sleep duration of 3.1 h., more than 1.5 h. longer than the durations reported by the other two aircraft groups. It is possible that the '400 aircraft is operated on longer flights, therefore more cruise time, than the other aircraft, or that '400 crews are augmented by only one crewmember (total of 3) instead of two (total of 4), allowing each crewmember more time in the bunk.

The groups also displayed significant differences concerning their reports of difficulties sleeping in the bunk ($F_{2,1340} = 39.23$, $p < .001$). The '100/200 group reported the most frequent difficulties, with an average response (3.7) approaching "often." The '400 group's average rating (3.3) was closer to "sometimes," and the MD-11 group reported the lowest frequency, with its average response (3.0) corresponding exactly to "sometimes" (see fig. 9). Post hoc Tukey tests showed significant differences ($p < .01$) among all three aircraft groups.

Overall attitude about the bunk ($F_{2,320} = 161.46$, $p < .001$) also differed significantly among the groups. MD-11 pilots gave the most positive rating, with an average response (4.5) midway between "positive" and "very positive"; the '400 group gave an average response (4.1) just above the "positive" level; and '100/200 crewmembers gave the most negative rating, with an average response (3.2) close to a rating of "neutral" (see fig. 10). Post hoc Tukey tests revealed significant differences ($p < .01$) among the ratings of the three aircraft types.

Consistent with these findings, ratings of how bunk sleep affected alertness also displayed a significant group difference ($F_{2,1345} = 59.29$, $p < .001$) (see fig. 11). Again, the MD-11 group returned the highest rating, an average response (4.5) midway between "improved" and "very improved." The '400 group also gave a positive rating, with an average response (4.3) better than "improved." The '100/200

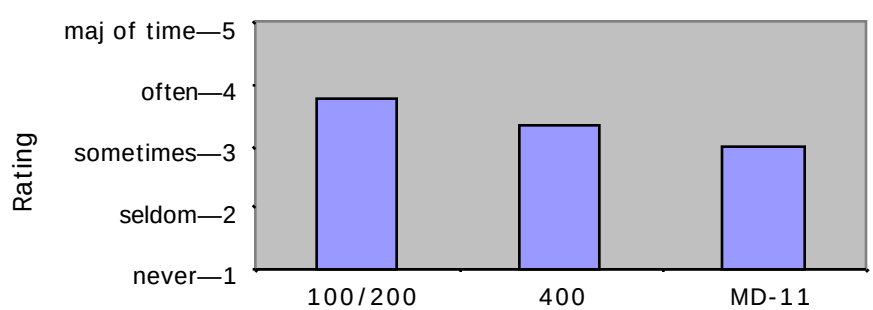


Figure 9. Ratings of difficulty sleeping in the bunk grouped by type of aircraft.

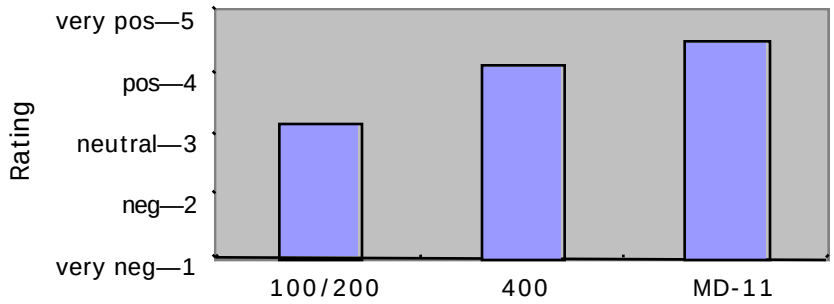


Figure 10. Overall ratings of the bunk grouped by type of aircraft.

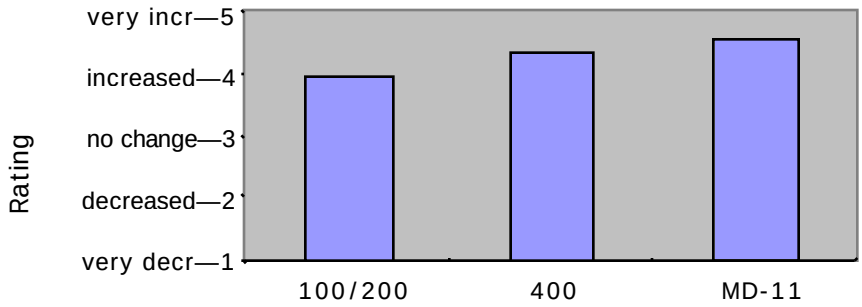


Figure 11. Ratings of how bunk sleep affected alertness grouped by type of aircraft.

group again gave the lowest rating, yet its average response (3.9) was just under the rating that corresponds to "improved" alertness. While post hoc Tukey tests showed the differences among the three aircraft groups to be significant ($p < .01$), each group nevertheless indicated that bunk sleep improved alertness. Also noteworthy is that the lowest individual rating from the MD-11 group was "no change"; no subjects from this group rated the bunk as having a negative effect on alertness. Very small percentages of the '400 group (2%) and the '100/200 group (6%) reported negative effects.

Similarly, ratings of bunk sleep's effect on performance displayed a significant group difference ($F_{2,1340} = 55.86$, $p < .001$) (see fig. 12). Again, the MD-11 group gave the highest rating, an average response (4.4) almost halfway between "improved" and "very improved." The '400 group also gave a high rating, with an average response (4.2) also better than "improved." As with the

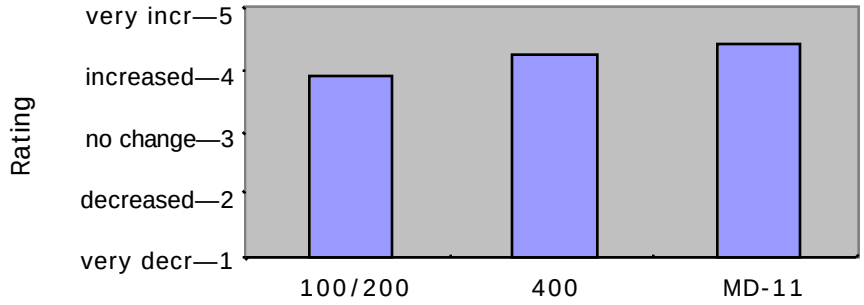


Figure 12. Ratings of how bunk sleep affected performance grouped by type of aircraft.

alertness effect, the ’100/200 group gave the lowest rating, an average response (3.9) slightly below the value that corresponds to “improved” performance. Post hoc Tukey tests showed that the rating of the ’100/200 was significantly lower ($p < .01$) than the ratings of the other two aircraft.

The 25 factors evaluated for their effects on bunk sleep were compared across aircraft type as well. The factors were assessed using the scale from -2 to 2, so that “interfere” responses were expressed as negative values and “promote” responses as positive values (see sec. 4.1.2). The scaled totals were analyzed across aircraft types using a Kruskal-Wallis rank test. While the ’100/200 and MD-11 showed a tendency towards difference, it was not statistically significant.

Figure 13 shows the average scaled ratings of some factors that appear to display differences among aircraft types. Several facility parameters exhibited differences, including facility size, bunk size, head space, storage space, and privacy. While the ’100/200 group rated each of these factors as interfering overall, both the ’400 and MD-11 groups rated each as promoting overall. One-way analysis of variance revealed significant differences for each of these factors ($p < .01$), with the ratings from the ’100/200 group identifying these factors as significantly more interfering than ratings from either of the other groups.

Also, the ratings for turbulence were significantly worse (i.e., rated as more interfering) for both the ’100/200 and the ’400 than for the MD-11. One-way analysis of variance indicated that turbulence ratings were significantly different ($F_{2,1346} = 25.72$, $p < .001$) across the three aircraft types. Post hoc Tukey tests showed significant differences ($p < .01$) among all three. Thus, turbulence was rated as being notably least interfering to sleep in the MD-11, and as most interfering in the ’400.

4.4.5 Bunk Sleep Difficulties, Special Analysis

Overall, the percentage of crewmembers reporting difficulty falling asleep in the bunk “often” or a “majority of time” (51%) differed significantly from that of crewmembers reporting difficulties at home with those frequencies (6%).

To explore any negative effect of the bunk facility on sleep, a special set of analyses was conducted. Subjects who rated themselves as

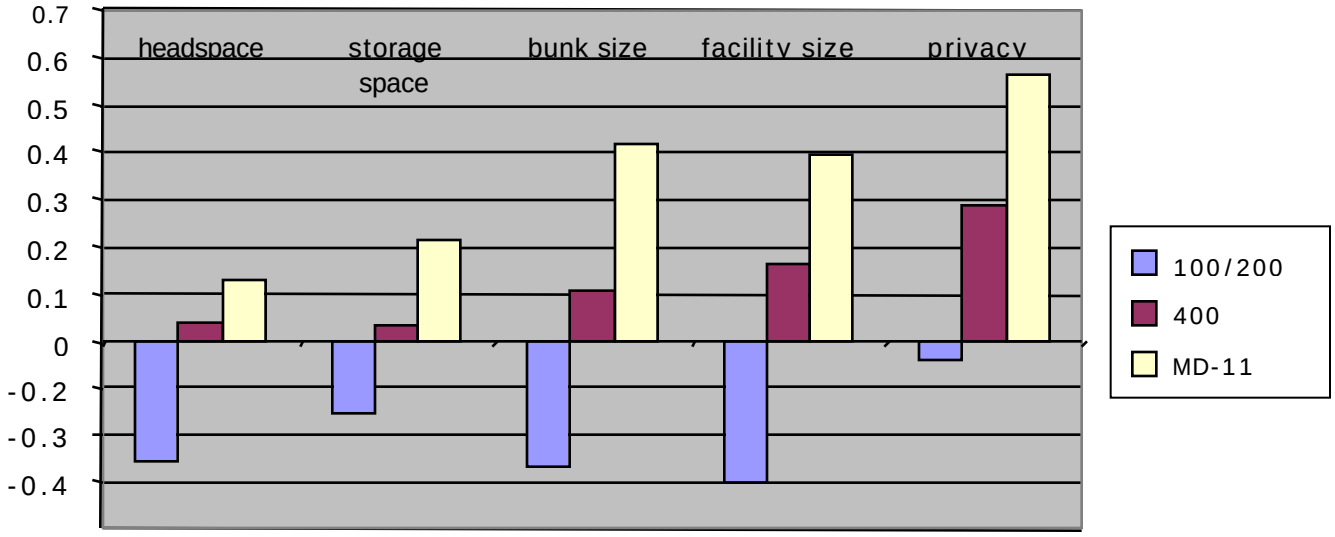


Figure 13. Rest facility parameters that exhibited significant differences among aircraft.

good sleepers at home were analyzed for difficulties sleeping in the bunk. This analysis was designed to expose the most extreme difference between good ability to sleep at home versus poor ability to sleep in the bunk. The bunk facility itself presumably would be one of the main variables that would account for the observed differences.

Combining data from the three carriers, 1254 subjects (91%) rated themselves as good home sleepers (i.e., "good" or "very good"). Of these, 1227 responded to a question on how frequently they experienced difficulty sleeping in the bunk (on a five-point scale from "never" to "majority of time"). Nearly half (47%) reported having difficulty sleeping in the bunk "often" or the "majority of time." If those who reported "sometimes" having difficulty are included, over three quarters (81%) of the good home sleepers reported having difficulty sleeping in the bunk.

The set of good home sleepers who reported having difficulties sleeping in the bunk "often" or the "majority of time" was compared to the set of good home sleepers who reported "never" or "seldom" having difficulties sleeping in the bunk. When the ages of these two groups were compared using a one-way analysis of variance, a significant difference ($F_{1, 798} = 13.28$, $p < .001$) was found. The group that reported fewer difficulties sleeping in the bunk was 2.5 yr. older on average (49.3 yr.) than the group that reported regular difficulties (46.8 yr.). This result is in contrast with the general finding that, under normal sleep conditions, older groups tend to experience more, rather than fewer, sleep difficulties than younger groups.

Of the subjects who reported being good home sleepers, 648 flew the '100/200 series aircraft. Of these, 58% reported having difficulty sleeping in the bunk "often" or the "majority of time." Crews of the '400 included 467 good home sleepers, with 37% reporting regular difficulties sleeping in the bunk. Good home sleepers from the MD-11 group numbered 96, with 28% reporting regular difficulties in the bunk.

When the good home sleepers who reported regular difficulties sleeping in the bunk were compared by aircraft type, a test for equality of proportions showed a significant difference ($\chi^2_{(2)} = 62.87$, $p < .001$). Post hoc pairwise comparisons revealed that the frequency of difficulties reported in the '100/200 was significantly greater than that in either the '400 ($\chi^2_{(1)} = 46.27$, $p < .001$) or the MD-11 ($\chi^2_{(1)} = 28.60$, $p < .001$). Thus, a significantly greater proportion of good home sleepers reported regular difficulties sleeping in the bunk of the '100/200 aircraft.

Comparing the sets of good home sleepers

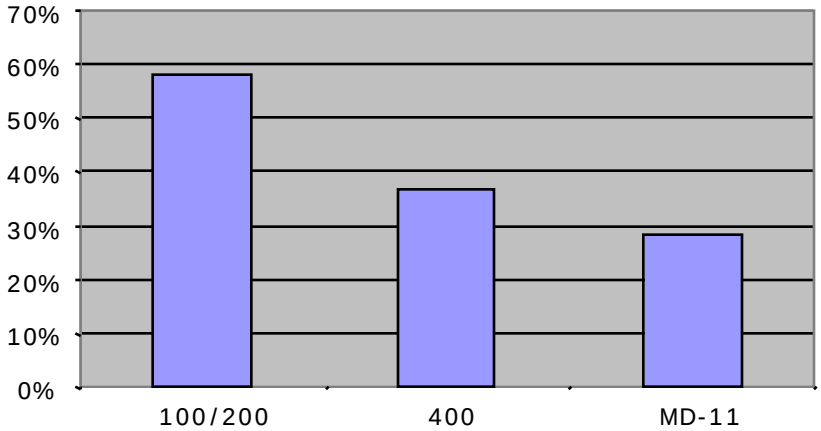


Figure 14. Good sleepers who reported regular difficulty sleeping in bunk, grouped by aircraft.

who reported "never" or "seldom" having difficulties sleeping in the bunk also revealed significant differences among aircraft types ($\chi^2_{(2)} = 28.77$, $p < .001$). Post hoc pairwise comparisons showed that each of the three groups differed from the other two. The MD-11 group reported the highest proportion (36%) of infrequent difficulties, which was significantly greater than the 22% of the '400 group who reported infrequent problems ($\chi^2_{(1)} = 8.17$, $p < .01$), and than the 15% of the '100/200 group ($\chi^2_{(1)} = 25.53$, $p < .001$). Additionally, the proportion of subjects who reported infrequent problems in the '400 was significantly greater ($\chi^2_{(1)} = 9.22$, $p < .01$) than in the '100/200.

The converse situation also was considered by examining poor home sleepers. Of the 128 subjects from all three carriers who reported being poor home sleepers, over 6% reported "seldom" having difficulty sleeping in the bunk. Further, while this group reported an average bunk sleep latency of nearly an hour (57.3 min.), it also reported a mean bunk sleep duration of 1.86 h., demonstrating that even poor home sleepers reported being able to sleep in the bunk once they fell asleep.

5.0 Discussion

5.1 Caveats

As in any operational study, certain factors are beyond the control of investigators. Therefore, limitations of the data should be kept in mind when drawing conclusions or making recommendations.

A survey study has the inherent limitation that the data gathered are subjective, and are therefore defined by the subject's perception, memory, and interpretation of the question. Additionally, subjectivity plays a well-documented role in people's perception of their sleep (ref. 13). Individuals are known to make inaccurate estimates of their sleep latency times, sleep durations, awakenings, and other parameters. In many of the survey questions, response choices included quantitative definitions (e.g., "often—1–4 times/wk") to avoid broad interpretation of descriptors. In other cases, subjects' perceptions were the targeted data (e.g., "Rate your overall attitude about the bunk."). Nevertheless, the subjective nature of survey data limits the generalizability of these results.

The data were statistically limited in that Carrier 2 was a much smaller data set than the other two carriers. While Carrier 2 had the highest return rate (49% return vs. 35% and 37% from Carriers 1 and 3, respectively), the number of surveys from Carrier 2 was much smaller (107 surveys compared with 737 surveys from Carrier 1 and 560 from Carrier 3). This discrepancy in sample size may have affected the ability to reach statistical significance in some of the analyses comparing the three carriers. Likewise, the set of MD-11 crewmembers was a much smaller set than those of the other two aircraft types. Confounding the matter, all of the MD-11 crewmembers were from Carrier 2, and all Carrier 2 crewmembers flew the MD-11. Therefore, it was impossible to isolate the factor (i.e., the aircraft vs. the carrier) that contributed to the MD-11 specific responses. Independent of any aircraft-type effect, the culture of a specific carrier, its hub location, or other characteristics may have affected responses from that carrier's crewmembers.

The same type of limitation arises from the fact that age and flight experience differed among carriers. Subjects from Carrier 3 were significantly older than those from Carrier 2, who were significantly older than Carrier 1 subjects. Consistent with the age difference, Carrier 3 crews had significantly more flight hours than did Carrier 1 crews. Therefore, the difference in age or flight hours may have contributed to any differences exhibited by carriers.

Similarly, findings may have been affected by the fact that rostering practices and bunk configurations most likely differed among aircraft types and across carriers. Company rostering practices can vary according to flight length, routes flown, aircraft performance

capability, company policy, contractual agreements, and other factors. These differences have several potential effects on bunk use, including the time of day of bunk periods, the duration of bunk periods, and previous sleep patterns of crewmembers. In addition to rostering variations, bunk configuration can differ among aircraft types and even among individual aircraft of the same type. Variations may have affected the comfort of the bunk, noise levels, or other aspects of a crewmember's experience of the facility.

Finally, the study results may not be generalized to situations that are beyond the scope of the scientific issues specifically addressed in this report

5.2 Findings

5.2.1 Sleep at Home

The subjects studied in all three carriers represent, on average, an average sleep population. This is evidenced by an average sleep duration of about 8 h., an average sleep latency of less than 20 min., few reports of regular difficulty sleeping, and few reports of specific sleep problems. Additionally, the vast majority rated themselves as "good" or "very good" sleepers at home.

5.2.2 Sleep in Bunk

Clearly, subjects were able to sleep in the bunk, as evidenced by the average bunk sleep duration of more than 1.5 h. Overall, subjects rated both alertness and performance as improved by bunk use, indicating that bunk sleep was perceived to have had a restorative effect. Even those subjects who rated themselves as poor sleepers at home reported being able to sleep in the bunk. While this subset of the surveyed group reported a long average sleep latency in the bunk (nearly an hour), they also reported an average sleep duration of 1.9 h., which was greater than the average sleep duration of the complete sample.

On the other hand, the time to fall asleep in the bunk was longer than at home, and a significantly greater percentage of crewmembers reported difficulty sleeping in the bunk than reported difficulty at home. Nearly half (47%) of those that rate themselves as good home sleepers reported having regular difficulties sleeping in the bunk.

5.2.3 Factors Affecting Sleep

The main factors identified by subjects as interfering with home sleep were essentially the same as those reported as interfering with bunk sleep. "Random noise," "thoughts running through your head," "trips to bathroom," and "heat," were the factors most commonly cited. Environmental disturbances (including noise) and personal disturbances (including trips to the bathroom) were two categories identified as contributing significantly to interference with both home sleep and bunk sleep. Concerning home sleep, environmental discomfort, including heat, also contributed. In the bunk, turbulence and light, including background lighting and the illuminated seat belt sign, were reported to interfere.

Random noise was identified with much greater frequency than was background noise (see fig. 7). This outcome suggests that the character of a noise may contribute to its disturbing effect. Some level of continuous background noise, in fact, may disguise random noises that might otherwise disturb a crewmember in the bunk.

"Thoughts running through your head" was identified as another factor that strongly interfered with both home sleep and bunk sleep. Anecdotal reports suggest that crewmembers remain concerned with the safety of operations even when they leave the flight deck for the bunk. Additional worries, personal or professional, may contribute to continuous thoughts that interfere with bunk sleep.

The main factors identified as promoting sleep at home were similar to those identified as promoting sleep in the aircraft bunk. Most commonly cited were pillows, readiness for sleep, blankets, sheets, and curtains. Three categories of factors found to promote sleep

both at home and in the bunk were sleep microenvironment, sleep preparedness, and sleep macroenvironment. The most frequently identified promoting factors were comfort items, including pillows, sheets, and blankets. Suggestions from crewmembers on how to improve the facility also focused on the microenvironment, and included larger and thicker mattresses, cloth sheets and pillow cases, and bigger pillows and blankets. The second category, preparedness, comprised readiness for sleep and comfort of clothing. An individual's readiness for sleep is a crucial and well documented component in the ability to sleep at a given time, and depends mainly on prior sleep/wake patterns and the time of day (i.e., place in the circadian cycle). In the macroenvironment category, a frequently identified factor affecting sleep was ventilation.

Interestingly, facility parameters such as the size of the crew rest facility, the size of the actual bunk, and head space were rated, on average, as having little effect in either direction. However, subjects' recommendations included significant mention of facility parameters, which indicates that the factors may be important to some crewmembers. Subjects' reactions to facility size, bunk size, and head space may depend greatly on height and body mass, resulting in a broad range of responses. The response scale in this question ranged from "interferes" to "promotes,"; therefore, if many crewmembers considered a factor (e.g., facility size) promoting while many others considered it interfering, when responses were averaged, they might appear to be a collective response of "no effect."

5.2.4 Aircraft Comparisons

Comparisons among the three aircraft types revealed consistently higher ratings for quality of sleep promotion in the MD-11 than in either of the B747 series. MD-11 crewmembers reported a better attitude about the bunk, shorter sleep latency, and fewer difficulties sleeping. Further, MD-11 crews rated subsequent alertness and performance as more improved by bunk sleep than did their '100/200 and '400 counterparts. Further, a significantly greater proportion of good home sleepers reported regular difficulties sleeping in the bunk of the '100/200 aircraft.

The longest sleep durations were reported by subjects from the '400. However, the '400 may have had longer flights or different rostering that allowed for longer bunk periods (see sec. 5.1). That is, there is no way to be certain to what extent the flight schedules and crew rostering in bunks within those schedules may have contributed to some of the reported difference between bunk sleep in the MD-11 versus the B747.

Factors affecting bunk sleep also were compared across aircraft type. The '100/200 aircraft, an older series, received the lowest ratings overall. Specifically, facility parameters including facility size, bunk size, head space, and privacy were rated as slightly interfering in the '100/200, whereas those factors were rated as somewhat promoting in each of the other aircraft (see sec. 5.2.3). For example, while the '100/200 group rated bunk size as an interfering factor (i.e., the bunk was presumably too small), the other two groups rated bunk size as a promoting factor (i.e., it was presumably a comfortable size). In addition, turbulence was rated as least interfering on the MD-11, and, surprisingly, most interfering on the '400, which is a newer series than the '100/200. The frequency of encountering turbulence may be affected by common weather patterns across routes, or by sheer length of the flights.

5.3 Recommendations

Several recommendations can be made based on the findings. Many are straightforward, and relatively simple to implement. The main factors identified as promoting sleep in the bunk were comfort items: pillows, sheets, blankets. Following suggestions from crewmembers by providing larger pillows and blankets, cloth sheets and pillow cases, and larger, thicker mattresses would be an easy, relatively inexpensive way to improve the benefits of the bunk facilities. Since comfort of clothing was another highly rated

promoting factor, providing time and space for crewmembers to change would be another simple improvement.

Factors identified as interfering with bunk sleep also suggest certain changes. Crewmembers indicated that random noise was a main interfering factor, and suggested that soundproofing might improve the bunk sleep environment. Additionally, other flight and cabin crewmembers can be made aware of the disturbing effects of random noise. Locating bunk facilities away from galleys and main passageways also may help minimize random noise events. The use of ear plugs represents another straightforward and cost effective strategy.

Another frequently identified interfering factor was thoughts. Thoughts and worries can be reduced through the use of mental focusing techniques and validated relaxation skills. These approaches are widely available through a variety of outlets and may help to minimize racing thoughts long enough to fall asleep. By providing access to training in such techniques, carriers can help crewmembers further optimize bunk sleep opportunities.

Subjects identified several environmental factors as affecting bunk sleep, including heat (interfered), cold (interfered), and ventilation (promoted). These findings suggest that better environmental controls in the facilities would promote bunk sleep. Also, based on the fact that “trips to bathroom” was rated as interfering, locating a crew lavatory near the bunk may also minimize disturbance. Finally, and perhaps most importantly, education can play a valuable role in maximizing the benefits of crew rest facilities.

The fact that readiness for sleep was identified as one of the main factors that promoted sleep suggests that this physiological component should be addressed. Educating crewmembers in basic sleep physiology may help them to plan their sleep more efficiently, to use caffeine strategically, and to practice other alertness management strategies that would enhance their ability to sleep during bunk periods. Education in sleep physiology has the added benefit of being applicable to general sleep health as well as to the challenges of jet lag and other long-haul issues. Educating cabin crewmembers, schedulers, dispatchers, managers, and other industry personnel also may have significant benefits that come from people in various parts of the system having the same understanding of fatigue issues and alertness management approaches.

Many of these recommendations are straightforward and inexpensive. These measures have the potential to benefit crewmembers by enabling them to obtain improved sleep quantity and quality during inflight bunk periods, and to benefit carriers by supporting alert, well-rested flight crews during long-haul operations. By optimizing existing crew rest facilities and addressing fatigue and alertness issues through other efforts, the long-haul industry can widen the safety margin and improve operational effectiveness.

References

1. Rosekind, M.R., Graeber, R.C., Dinges, D.F., Connell, L.J., Rountree, M.S., Spinweber, C.L., & Gillen, K.A. (1994). Crew Factors in Flight Operations IX: Effects of Planned Cockpit Rest on Crew Performance and Alertness in Long-Haul Operations. NASA Technical Memorandum 108839. Moffett Field, CA: NASA Ames Research Center.

2. Gander, P. H., Graeber, R. C., Connell, L. J., and Gregory, K. B. (1991). Crew factors in flight operations: VIII. Factors Influencing Sleep Timing and Subjective Sleep Quality in Commercial Long-Haul Flight Crews. (Technical Memorandum 103852). Moffett Field, CA: National Aeronautics and Space Administration.

3. Graeber, R.C. (1986). Crew factors in flight operations: IV. Sleep and Wakefulness in International Aircrews. (Technical Memorandum 88231). Moffett Field, CA: National Aeronautics and Space Administration.

4. Rosekind, M. R., Gregory, K. B., Miller, D. L., Co, E. L., and Lebacqz, J. V. Aircraft Accident Report: Uncontrolled Collision with Terrain, American International Airways Flight 808, Douglas DC-8, N814CK, U.S. Naval Air Station, Guantanamo Bay, Cuba, August 18, 1993. (No. NTSB/AAR-94/04). Washington, DC: National Transportation Safety Board, 1994.

5. National Transportation Safety Board. (1999). Aircraft Accident Report: Controlled Flight into Terrain, Korean Air Flight 801, Boeing 747-300, HL7468, Nimitz Hill, Guam, August 6, 1997. (No. NTSB/AAR-99/02). Washington, DC: National Transportation Safety Board.

6. Graeber, R. C. (1988). Aircrew Fatigue and Circadian Rhythmicity. In E. L. Weiner and D. C. Nagel (Eds.), Human Factors in Aviation (pp. 305-344). New York: Academic Press, Inc.

7. Federal Aviation Administration. (1999.) FAA Aerospace Forecasts—Fiscal Years 1999–2010. (FAA Publication No. FAA APO-99-1.) Washington, DC: Author.

8. Broughton, R.J. & Ogilvie, R.D. (Eds.). (1992). Sleep, Arousal, and Performance. Boston: Birkhauser.

9. Dinges, D.F. & Kribbs, N.B. (1991). Performing while sleepy: effects of experimentally-induced sleepiness. In T.H. Monk (Ed.), Sleep, Sleepiness and Performance, (pp. 97–128). Chichester: Wiley.

10. Carskadon, M.A. & Roth, T. (1991). Sleep Restriction. In T.H. Monk (Ed.), Sleep, Sleepiness, and Performance (pp. 155–167). Chichester, UK: John Wiley and Sons, Ltd.

11. Zarcone, V.P. (1994). Sleep Hygiene. In M.H. Kryger, T. Roth, and W.C. Dement (Eds.), Principles and Practice of Sleep Medicine (2nd Edition) (pp. 542–546). Philadelphia: W.B. Sauders Co.

12. Folkard S. & Monk TH. (1979). Shiftwork and Performance. Human Factors, 21:483–492.

13. Sasaki, M., Kurosaki, Y., Mori, A., and Endo, S. (1986) Patterns of Sleep-Wakefulness Before and After Transmeridian Flight in Commercial Airline Pilots. In R.C. Graeber (Ed.) Crew Factors in Flight Operations: IV. Sleep and Wakefulness in International Aircrews. (Technical Memorandum 88231). Moffett Field, CA: National Aeronautics and Space Administration.

Appendix A
General Survey

A. GENERAL

1. What is your flightdeck position? Capt. ☐ F/O ☐ S/O or F/E ☐

2. What aircraft are you currently operating? B747 series ☐ B747-400 ☐ B767 series ☐ A300 series ☐ MD-11 ☐ other (please specify) ☐

3. How many total flight hours have you logged? ☐

4. How much experience do you have flying long-haul? ☐ yrs ☐ mos

5. Gender? ☐ male ☐ female

6. Age? ☐

7. What is your weight? ☐ lbs. **OR** ☐ kg.

8. What is your height? ☐ ft. ☐ ins. **OR** ☐ cm.

9. In what time-zone do you live? ☐

10. In what time-zone relative to GMT do you live? ☐ hrs (specify + or -)

11. Do you have a regular bed partner? yes ☐ no ☐

12. Number of children at home under 18 years of age? ☐

13. Number of others living with you? (e.g., older children, In Laws, relatives) ☐

14. Specify: _____

B. SLEEPING AT HOME

Please give one best answer to each of the following questions based on **an average night of sleep at home**. (About 3-4 days after your return home following a long-haul trip).

15. On your days off, what time do you usually go to sleep? **(Use 24 hr. clock)** ☐☐ hrs ☐☐ mins

16. On your days off, what time do you usually get up? **(Use 24 hr. clock)** ☐☐ hrs ☐☐ mins

17. On your days off, how long after going to bed do you usually take to fall asleep? ☐☐ hrs ☐☐ mins

18. When sleeping at home, how many times on average do you wake up? ☐ times

19. If you wake during the night, what is it that usually causes you to awaken? _____

20. If you wake during the night, on average, how long does it take you to go back to sleep? ☐☐ hrs ☐☐ mins

21. When sleeping at home, what is the usual amount of total sleep you get? ☐☐ hrs ☐☐ mins

22. How often do you take a daytime nap at home?

never	seldom	sometimes	often	majority of time
	1-4 times/yr	1-3 times/mo	1-4 times/wk	5-7times/wk
☐	☐	☐	☐	☐

23. When sleeping at home, do you have problems getting to sleep?

never	seldom	sometimes	often	majority of time
	1-4 times/yr	1-3 times/mo	1-4 times/wk	5-7 times/wk
☐	☐	☐	☐	☐

REMEMBER: give one best answer based on an average night of sleep at home (about 3-4 days after you return from a long-haul trip).

24. Please rate the following factors and indicate how much they **interfere with or promote** your sleep at home?

	interferes 1	2	no effect 3	4	promotes 5
1) quality of sleep surface	☐	☐	☐	☐	☐
2) heat	☐	☐	☐	☐	☐
3) cold	☐	☐	☐	☐	☐
4) thoughts running through your head	☐	☐	☐	☐	☐
5) random noise events	☐	☐	☐	☐	☐
6) constant background noise	☐	☐	☐	☐	☐
7) background lighting	☐	☐	☐	☐	☐
8) readiness for sleep	☐	☐	☐	☐	☐
9) comfort of clothing	☐	☐	☐	☐	☐
10) low humidity/dry air	☐	☐	☐	☐	☐
11) high humidity	☐	☐	☐	☐	☐
12) trips to bathroom	☐	☐	☐	☐	☐
13) bed partner	☐	☐	☐	☐	☐
14) privacy	☐	☐	☐	☐	☐
15) ventilation	☐	☐	☐	☐	☐
16) sheets	☐	☐	☐	☐	☐
17) blankets	☐	☐	☐	☐	☐
18) pillows	☐	☐	☐	☐	☐
19) other (specify) _____	☐	☐	☐	☐	☐

25. Please rate the following on the extent to which they **interfere** with your sleep at home?

	strongly interferes 1	2	3	4	no effect 5
1) hunger	☐	☐	☐	☐	☐
2) thirst	☐	☐	☐	☐	☐
3) personal worries	☐	☐	☐	☐	☐
4) respiratory factors (i.e.asthma, allergies, etc.)	☐	☐	☐	☐	☐
5) other (specify) _____	☐	☐	☐	☐	☐

26. Please list any other factors that **promote** your sleep at home.

1._____

2._____

3._____

4._____

5._____

REMEMBER: give one best answer based on an average night of sleep at home (about 3-4 days after you return from a long-haul trip).

27. Do you take medication to help you sleep?

never	seldom 1-4 times/yr	sometimes 1-3 times/mo	often 1-4 times/wk	majority of time 5-7 times/wk
☐	☐	☐	☐	☐

28. If yes, please specify. _____

29. Do you ever use alcohol to help you sleep?

never	seldom 1-4 times/yr	sometimes 1-3 times/mo	often 1-4 times/wk	majority of time 5-7 times/wk
☐	☐	☐	☐	☐

30. Overall, what kind of sleeper are you?

very poor	poor	good	very good
☐	☐	☐	☐

31. Do you have a sleep problem?

yes	no
☐	☐

32. If yes, what is your sleep problem. _____

33. If yes, has it been diagnosed by a physician?

yes	no
☐	☐

34. Has it ever prevented you from flying a scheduled trip?

yes	no
☐	☐

Fill out this section **ONLY** if you are currently flying an aircraft equipped with a bunk.

C. SLEEPING IN AIRCRAFT BUNKS

Please give one best answer to each of the following questions based on experiences in your aircraft.

35. How often have you used a bunk in the past 12 months?
    1) current aircraft ☐ times
    2) other types of aircraft ☐ times

36. Based on your current aircraft, which bunk do you usually sleep in?
    upper ☐ lower ☐ either ☐

37. Are you able to undress for a comfortable sleep?
    yes ☐ no ☐

38. Is it important for you to undress for a comfortable sleep?
    yes ☐ no ☐

39. How long after getting into the bunk does it take you to fall asleep?
    ☐☐ hrs ☐☐ mins

    a) What is the typical amount of sleep you get in the bunk?
    ☐☐ hrs ☐☐ mins

    b) What is the longest sleep period you have experienced in the bunk?
    ☐☐ hrs ☐☐ mins

    c) What is the shortest period of time that you would use the bunk for sleep?
    ☐☐ hrs ☐☐ mins

40. When you have an opportunity to use the bunk how often do you experience difficulty sleeping?
    never ☐ seldom ☐ sometimes ☐ often ☐ majority of time ☐

    a) How often do you use the bunk only for rest and not sleep?
    never ☐ seldom ☐ sometimes ☐ often ☐ majority of time ☐

41. Are you required to spend some time in the bunk when not flying?
    yes ☐ no ☐

42. If yes, who or what mandates use?
    Co. policy ☐ Sr. Capt. ☐ Capt ☐ flt. length ☐ other(specify) ☐

43. What other factors determine bunk use and rostering?
    1._____
    2._____

3._____

4._____

44. In general, what percentage of cruise time is made available to you for using the bunk?

_____%

45. Rate your overall attitude about the bunk.

very neg	neg	neutral	pos	very pos
☐	☐	☐	☐	☐

46. How does bunk sleep affect your overall alertness?

very decreased alertness	decreased alertness	no change	improved alertness	very improved alertness
☐	☐	☐	☐	☐

47. How does bunk sleep affect your performance?

very decreased performance	decreased performance	no change	improved performance	very improved performance
☐	☐	☐	☐	☐

48. How often can you sleep when you use any of the following.

	never	seldom	sometimes	often	almost always
1) cockpit seat	☐	☐	☐	☐	☐
2) 1st class seat	☐	☐	☐	☐	☐
3) passenger seat	☐	☐	☐	☐	☐
4) bunk	☐	☐	☐	☐	☐
5) at home in bed	☐	☐	☐	☐	☐

This is one of the most important questions in this survey.
Please take your time and answer thoroughly.

49. Please rate the following factors and indicate how much they **interfere with or promote** your sleep in the bunk?

	interferes 1	2	no effect 3	4	promotes 5
1) quality of sleep surface	☐	☐	☐	☐	☐
2) heat	☐	☐	☐	☐	☐
3) cold	☐	☐	☐	☐	☐
4) thoughts running through your head	☐	☐	☐	☐	☐
5) random noise events	☐	☐	☐	☐	☐
6) constant background noise	☐	☐	☐	☐	☐
7) background lighting	☐	☐	☐	☐	☐
8) readiness for sleep	☐	☐	☐	☐	☐
9) comfort of clothing	☐	☐	☐	☐	☐
10) low humidity/dry air	☐	☐	☐	☐	☐
11) trips to bathroom	☐	☐	☐	☐	☐
12) someone in the other bunk	☐	☐	☐	☐	☐
13) seat belt sign	☐	☐	☐	☐	☐
14) turbulence	☐	☐	☐	☐	☐
15) privacy	☐	☐	☐	☐	☐
16) bunk size	☐	☐	☐	☐	☐
17) facility size	☐	☐	☐	☐	☐
18) headspace	☐	☐	☐	☐	☐
19) lighting	☐	☐	☐	☐	☐
20) ventilation	☐	☐	☐	☐	☐
21) storage space	☐	☐	☐	☐	☐
22) curtains	☐	☐	☐	☐	☐
23) sheets	☐	☐	☐	☐	☐

24) blankets	☐	☐	☐	☐	☐
25) pillows	☐	☐	☐	☐	☐
26) other (specify) _____	☐	☐	☐	☐	☐

50. Please rate the following on the extent to which they **interfere** with your sleep in the bunk?

	strongly interferes 1	2	3	4	no effect 5
1) hunger	☐	☐	☐	☐	☐
2) thirst	☐	☐	☐	☐	☐
3) claustrophopia	☐	☐	☐	☐	☐
4) personal worries	☐	☐	☐	☐	☐
5) respiratory factors (i.e. asthma, allergies, etc.)	☐	☐	☐	☐	☐
6) other (specify) _____	☐	☐	☐	☐	☐

51. Please list any other factors that **promote** good sleep in the bunk.

1._____

2._____

3._____

4._____

5._____

52. When using the bunk, do you do anything to help you get to sleep or to minimize disturbance of your sleep, such as:

	yes	no
1) Wear earplugs?	☐	☐
2) Wear eyeshades?	☐	☐
3) Listen to music?	☐	☐
4) Relaxation techniques?	☐	☐

5) Other (specify) _____

53. Describe any **pre-trip** strategies you use to help you sleep in the bunk. (things you do **before** you are on the aircraft!)

1)_____

2)_____

3)_____

4)_____

54. Please suggest how the crew rest facility can be improved to be more conducive to

1)_____

sleep?

2)_____

3)_____

4)_____

Thank you very much for completing this survey. Please return it to NASA by sending it in the enclosed, stamped envelope.

COMMENTS:

Appendix B
Survey Results: Carrier 1

Appendix B
Survey Results: Carrier 1

Surveys sent out: 2125 Surveys received: 737 (35% return)

1. What is your flightdeck position?
(there were also 5 IRP entries)

Capt.	F/O	S/O or F/E
303 (41%)	276 (38%)	147 (20%)

2. What aircraft are you currently operating?

B747 series	B747-400	B767 series
498 (68%)	229 (31%)	0

A300 series	MD-11	other (please specify)
1	1	

3. How many total flight hours have you logged?

$\bar{x}$ = 12,522
S.D. = 6,156

min 400 ⟷ max 30,000

4. How much experience do you have flying long-haul?

$\bar{x}$ = 8.76
S.D. = 7.24
yrs

min 1 mo. ⟷ max 40 yrs.

5. Gender?

male	female
727 (99%)	10 (1%)

6. Age?

$\bar{x}$ = 44.5
S.D. = 8.2

min 27 ⟷ max 63

7. What is your weight?

$\bar{x}$ = 183.6
S.D. = 23.6 lbs.

min 117 ⟷ max 300

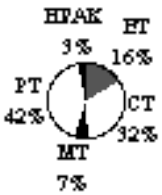
8. What is your height?

$\bar{x}$ = 71.3
S.D. = 2.3 ins.

min 63 ⟷ max 79

9. In what time-zone do you live?

Pacific (PT) =	306
Central (CT) =	232
Eastern (ET) =	117
Mountain (MT) =	50
Hawaii (HI) =	15
Alaska (AK) =	6



10. In what time-zone relative to GMT do you live?

Results were inconclusive.

11. Do you have a regular bed partner?

yes		no	
647	89%	84	11%

12. Number of children at home under 18 years of age?

No children =	379
1 or more children =	353

13. Number of others living with you?
(e.g., older children, In Laws, relatives)

Results were inconclusive.

14. Specify:

Results were inconclusive.

B. SLEEPING AT HOME

15. On your days off, what time do you usually go to sleep? (Use 24 hr. clock)

$\bar{x}$ = 22:58
S.D. = 0:29
hrs

min 2000 ⟷ max 0300

16. On your days off, what time do you usually get up? (Use 24 hr. clock)

$\bar{x}$ = 07:19
S.D. = 0:35
hrs

min 0311 ⟷ max 1400

17. On your days off, how long after going to bed do you usually take to fall asleep?

$\bar{x}$ = 19.4
S.D. = 27.5
mins

min 1 ⟷ max 180

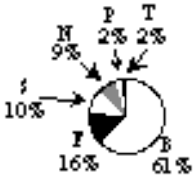
18. When sleeping at home, how many times <u>on average</u> do you wake up?

$\bar{x}$ = 1.4
S.D. = 1.1
times

min 0 ⟷ max 10

19. If you wake during the night, what is it that usually causes you to awaken?

Physiological (B) (bathroom)	420
Children/spouse/pets (F)	103
Can't sleep (S)	65
Noise (N)	57
Pain (P)	15
Thirst (T)	11



20. If you wake during the night, on average, how long does it take you to go back to sleep?

$\bar{x}$ = 12.8
S.D. = 14.1
mins

min 1 ⟷ max 90

21. When sleeping at home, what is the usual amount of total sleep you get?

$\bar{x}$ = 7:47
S.D. = 2:45
hrs

min 4:11 ⟷ max 11:00

22. How often do you take a daytime nap at home?

never	seldom	sometimes	often	majority of time
152 (21%)	247 (35%)	223 (31%)	90 (12%)	10 (1%)

23. When sleeping at home, do you have problems getting to sleep?

never	seldom	sometimes	often	majority of time
86 (12%)	374 (52%)	216 (30%)	35 (5%)	9 (1%)

24. Please rate the following factors and indicate how much they <u>interfere with or promote</u> your sleep at home?

	interfere 1	2	no effect 3	4	promotes 5
1) quality of sleep surface	39 (5%)	67 (9%)	86 (12%)	215 (30%)	312 (44%)
2) heat	215 (30%)	286 (39%)	101 (14%)	99 (14%)	18 (3%)
3) cold	59 (8%)	178 (25%)	150 (21%)	235 (33%)	96 (13%)
4) thoughts running through head	273 (38%)	359 (51%)	74 (10%)	9 (1%)	1 (0%)
5) random noise events	152 (21%)	364 (50%)	192 (27%)	11 (2%)	3 (0%)
6) constant background noise	71 (10%)	208 (29%)	343 (48%)	68 (9%)	31 (4%)
7) background lighting	113 (16%)	287 (40%)	290 (40%)	20 (3%)	8 (1%)
8) readiness for sleep	33 (5%)	67 (9%)	84 (12%)	251 (35%)	286 (39%)
9) comfort of clothing	24 (3%)	61 (9%)	232 (32%)	242 (34%)	157 (22%)
10) low humidity/dry air	89 (12%)	197 (27%)	321 (46%)	73 (10%)	37 (5%)
11) high humidity	146 (20%)	274 (38%)	252 (35%)	40 (6%)	7 (1%)
12) trips to bathroom	148 (20%)	354 (49%)	209 (29%)	7 (1%)	5 (1%)
13) bed partner	13 (1%)	113 (16%)	335 (46%)	162 (22%)	98 (14%)
14) privacy	11 (2%)	50 (7%)	279 (38%)	228 (32%)	155 (21%)
15) ventilation	7 (1%)	65 (9%)	140 (19%)	335 (47%)	177 (24%)
16) sheets	15 (2%)	32 (4%)	164 (23%)	295 (41%)	216 (30%)

17) blankets	9	1%	42	6%	148	21%	318	44%	204	28%
18) pillows	25	3%	38	5%	98	35%	250	35%	306	43%

interfere — promotes

Environment	35
Comfort	20
Mental attitude	16
Physical activity	11

19) other (specify) — No substantial findings

24. Please rate the following factors and indicate how much they interfere with or promote your sleep at home?

(results are shown as %'s of total responses in each column)

	interfere 1	2	no effect 3	4	promotes 5
1) quality of sleep surface	2.7	2.2	2.5	7.5	14.8
2) heat	14.9	9.4	2.9	3.5	0.9
3) cold	4.1	5.9	4.3	8.3	4.6
4) thoughts running through head	19.0	11.9	2.1	0.3	0.1
5) random noise events	10.5	11.9	5.5	0.4	0.1
6) constant background noise	4.9	6.8	9.8	2.4	1.5
7) background lighting	7.9	9.5	8.3	0.7	0.4
8) readiness for sleep	2.3	2.2	2.4	8.8	13.5
9) comfort of clothing	1.7	2.0	6.7	8.5	7.5
10) low humidity/dry air	6.2	6.5	9.2	2.6	1.8
11) high humidity	10.1	9.0	7.2	1.4	0.3
12) trips to bathroom	10.2	11.6	6.0	0.2	0.2
13) bed partner	0.9	3.7	9.6	5.7	4.6
14) privacy	0.8	1.6	7.9	8.0	7.3
15) ventilation	0.5	2.1	4.0	11.7	8.3
16) sheets	1.0	1.1	4.7	10.3	10.2
17) blankets	0.6	1.4	4.2	11.1	9.6
18) pillows	1.7	1.3	2.8	8.8	14.5

25. Please rate the following on the extent to which they *interfere* with your sleep at home?

	strongly interferes 1		2		3		4		no effect 5	
1) hunger	36	5%	165	23%	169	24%	146	20%	201	28%
2) thirst	72	10%	235	32%	179	25%	134	19%	101	14%
3) personal worries	172	24%	257	36%	157	22%	96	19%	36	5%

4) respiratory factors

28	4%	98	14%	159	23%	59	8%	362	51%

5) other (specify)

Jetlag	29
Noise	14
Mental attitude	13
Environment	12
Family/pets	12

26. Please list any other factors that *promote* your sleep at home.

Physical environment (PE)	336
Mental attitude (MA)	180
Pre-sleep activities (PSA)	156
Exercise/physical activity (EX)	137
Comfort (C)	129
Schedule (S)	92
Meals/food (M)	40
Alcohol/medication (A)	35

27. Do you take medication to help you sleep?

never		seldom		sometimes		often		majority of time	
612	84%	72	10%	40	5%	4	1%	0	0%

28. If yes, please specify.

Cold remedies/aspirin	50
Sleeping pills	39
Allergy medication	3

29. Do you ever use alcohol to help you sleep?

never		seldom		sometimes		often		majority of time	
523	72%	118	16%	68	9%	15	2%	4	1%

30. Overall, what kind of sleeper are you?

very poor		poor		good		very good	
3	0%	64	9%	385	53%	275	38%

31. Do you have a sleep problem?

yes		no	
77	11%	648	89%

32. If yes, what is your sleep problem.

Circadian disruption	32
Restless sleeper	19
Talk/Snore/Apnea	10
Thoughts/worries	8
Pain	5

33. If yes, has it been diagnosed by a physician?

yes		no		no answer	
6	1%	204	28%	516	71%

34. Has it ever prevented you from flying a scheduled trip?

yes		no		no answer	
6	1%	352	48%	369	51%

C. SLEEPING IN AIRCRAFT BUNKS

35. How often have you used a bunk in the past 12 months?

1) current aircraft — $\bar{x}$ = 21.08, S.D. = 20.41 **times** — min 0 ⟷ max 99

2) other types of aircraft — $\bar{x}$ = 1.59, S.D. = 7.09 **times** — min 0 ⟷ max 99

36. Based on your current aircraft, which bunk do you usually sleep in?

upper	lower	either
258 (36%)	225 (31%)	234 (33%)

37. Are you able to undress for a comfortable sleep?

yes	no
630 (88%)	88 (12%)

38. Is it important for you to undress for a comfortable sleep?

yes	no
583 (81%)	136 (19%)

39. How long after getting into the bunk does it take you to fall asleep? — $\bar{x}$ = 44.12, S.D. = 31.70 **mins** — min 2 ⟷ max 180

40. When you have an opportunity to use the bunk how often do you experience difficulty sleeping?

never	seldom	sometimes	often	majority of time
11 (2%)	92 (13%)	227 (31%)	199 (28%)	188 (26%)

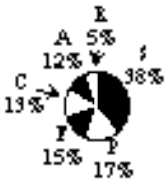
41. Are you required to spend <u>some</u> time in the bunk when not flying?

yes	no
53 (7%)	664 (93%)

42. If yes, who or what mandates use? <u>Results were inconclusive.</u>

43. What other factors determine bunk use and rostering?

Seniority/crew decision (S)	229
Prefer alternate choice (P)	99
Schedule/flight operations (F)	82
Sleep/circadian factors (C)	75
Augmentation (A)	70
Random selection (R)	30
Concern with flight/operations (F)	8



44. In general, what percentage of cruise time is made available to you for using the bunk? — $\bar{x}$ = 32.61, S.D. = 12.69 **%** — min 4 ⟷ max 99

45. Rate your overall attitude about the bunk.

very neg	neg	neutral	pos	very pos
50 (7%)	169 (24%)	142 (20%)	243 (33%)	111 (16%)

46. How does bunk sleep affect your overall alertness?

very decreased alertness	decreased alertness	no change	improved alertness	very improved alertness
4 (1%)	32 (4%)	65 (9%)	456 (64%)	160 (22%)

47. How does bunk sleep affect your overall performance?

very decreased performance	decreased performance	no change	improved performance	very improved performance
5 (1%)	28 (4%)	92 (13%)	479 (66%)	111 (16%)

48. How often can you sleep when you use any of the following.

	never	seldom	sometimes	often	almost always
1) cockpit seat	205 (29%)	247 (34%)	195 (27%)	57 (8%)	15 (2%)
2) 1st class seat	45 (6%)	180 (25%)	297 (42%)	138 (19%)	60 (8%)
3) passenger seat	184 (26%)	347 (48%)	143 (20%)	36 (5%)	5 (1%)

49. Please rate the following factors and indicate how much they <u>interfere with or promote</u> your sleep in the bunk?

	interfere 1	2	no effect 3	4	promotes 5
1) quality of sleep surface	130 (18%)	215 (30%)	114 (16%)	120 (17%)	135 (19%)
2) heat	197 (27%)	308 (43%)	113 (16%)	87 (12%)	13 (2%)
3) cold	117 (16%)	279 (39%)	130 (18%)	150 (21%)	44 (6%)
4) thoughts running through head	215 (30%)	355 (49%)	140 (20%)	4 (1%)	2 (0%)
5) random noise events	327 (46%)	282 (39%)	100 (14%)	7 (1%)	2 (0%)
6) constant background noise	107 (15%)	222 (31%)	256 (36%)	103 (14%)	31 (4%)
7) background lighting	102 (14%)	295 (41%)	293 (41%)	21 (3%)	5 (1%)
8) readiness for sleep	118 (16%)	92 (13%)	55 (8%)	247 (35%)	204 (28%)
9) comfort of clothing	51 (7%)	118 (16%)	139 (19%)	287 (41%)	123 (17%)
10) low humidity/dry air	136 (19%)	239 (33%)	272 (39%)	51 (7%)	17 (2%)
11) trips to bathroom	232 (32%)	285 (39%)	199 (27%)	3 (0%)	17 (2%)

12) someone in the other bunk	89 (12%)	257 (35%)	373 (51%)	3 (0%)	17 (2%)
13) seat belt sign	68 (9%)	163 (22%)	483 (67%)	3 (0%)	17 (2%)
14) turbulence	198 (28%)	369 (51%)	108 (15%)	37 (5%)	8 (1%)
15) privacy	54 (8%)	190 (26%)	283 (39%)	114 (16%)	79 (11%)
16) bunk size	104 (14%)	219 (31%)	210 (29%)	116 (16%)	71 (10%)
17) facility size	94 (13%)	193 (27%)	270 (37%)	113 (16%)	49 (7%)
18) headspace	82 (11%)	190 (26%)	309 (44%)	93 (13%)	43 (6%)
19) lighting	48 (7%)	203 (28%)	365 (51%)	89 (12%)	13 (2%)
20) ventilation	50 (7%)	175 (24%)	220 (31%)	209 (29%)	64 (9%)
21) storage space	31 (4%)	113 (16%)	501 (70%)	62 (9%)	10 (1%)
22) curtains	27 (4%)	60 (9%)	320 (45%)	156 (22%)	141 (20%)
23) sheets	189 (26%)	136 (19%)	85 (12%)	154 (22%)	152 (21%)
24) blankets	93 (13%)	118 (16%)	110 (15%)	223 (32%)	176 (24%)
25) pillows	118 (16%)	132 (18%)	88 (12%)	173 (24%)	207 (30%)

26) other (specify)

interfere		promotes	
Noise	51	Comfort (bedding)	42
(wear earplugs)	10	Positive mental attitude	9

49. Please rate the following factors and indicate how much they <u>interfere with or promote</u> your sleep in the bunk?

(results are shown as %'s of total responses in each column)

	interfere 1	2	no effect 3	4	promotes 5
1) quality of sleep surface	4.4	4.2	2.1	4.6	8.5
2) heat	6.6	5.9	2.0	3.3	0.8
3) cold	3.9	5.3	2.3	5.7	2.8
4) thoughts running through head	7.2	6.8	2.5	0.2	0.1
5) random noise events	11.0	5.4	1.8	0.3	0.0
6) constant background noise	3.6	4.3	4.6	3.9	2.0
7) background lighting	3.4	5.7	5.3	0.8	0.3
8) readiness for sleep	4.0	1.8	1.0	9.4	12.9
9) comfort of clothing	1.7	2.3	2.5	10.9	7.7

10) low humidity/dry air	4.6	4.6	4.9	2.0	1.1
11) trips to bathroom	7.8	5.5	3.6	0.1	0.0
12) bunk partner	3.0	4.9	6.7	0.0	0.0
13) seat belt sign	2.3	3.1	8.7	0.0	0.1
14) turbulence	6.6	7.1	1.9	1.4	0.5
15) privacy	1.8	3.6	5.1	4.3	5.0
16) bunk size	3.5	4.2	3.8	4.4	4.4
17) facility size	3.2	3.7	4.9	4.3	3.1
18) headspace	2.8	3.6	5.6	3.6	2.7
19) lighting	1.6	3.9	6.6	3.4	0.8
20) ventilation	1.7	3.4	4.0	8.0	4.0
21) storage space	1.0	2.2	9.0	2.4	0.6
22) curtains	0.9	1.2	5.9	6.1	9.0
23) sheets	6.4	2.6	1.5	5.9	9.6
24) blankets	3.1	2.3	2.0	8.5	11.0
25) pillows	4.0	2.5	1.6	6.6	13.0

50. Please rate the following on the extent to which they <u>interfere</u> with your sleep in the bunk?

	strongly interferes 1	2	3	4	no effect 5
1) hunger	34 (5%)	164 (23%)	166 (23%)	136 (19%)	214 (30%)
2) thirst	77 (11%)	213 (30%)	184 (26%)	117 (16%)	124 (17%)
3) claustrophopia	22 (3%)	56 (8%)	165 (23%)	64 (9%)	404 (57%)
4) personal worries	88 (12%)	150 (21%)	197 (28%)	150 (21%)	125 (18%)
5) respiratory factors	18 (3%)	66 (9%)	147 (21%)	69 (10%)	395 (57%)

6) other (specify)

Noise	75
Bunk comfort	63
Environment	35
Bathroom	33
Scheduling	16
Turbulence	4
Mental attitude	4

51. Please list any other factors that <u>promote</u> good sleep in the bunk.

Comfort (C)	292
Environment (E)	270
Fatigue (FATG)	132
Length of break (B)	60
Ease of mind (M)	56
Lack of turbulence (T)	55
Privacy (P)	51
Food (FD)	34

52. When using the bunk, do you do anything to help you get to sleep or to minimize disturbance of your sleep, such as:

	yes		no	
1) Wear earplugs?	398	44%	312	44%
2) Wear eyeshades?	73	11%	622	89%
3) Listen to music?	80	11%	617	89%
4) Relaxation techniques?	166	25%	501	75%

5) Other (specify)

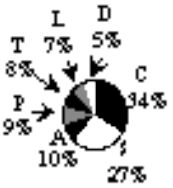
Read	93
Comfort aids	30

53. Describe any <u>pre-trip</u> strategies you use to help you sleep in the bunk.

Schedule sleep (S)	246
Bring comfort aids (A)	137
Avoid caffeine (C)	44
Limit food intake (F)	40
Limit liquids (L)	30
Exercise (E)	18
Rest (R)	14
Settle problems (P)	4

54. Please suggest how the crew rest facility can be improved to be more conducive to sleep?

Comfort (C) (mattress,pillows,sheets,blankets)	509
Sound proofing (S)	409
Larger bunk area (A)	145
Privacy (P)	134
Humidifier/temperature control (T)	124
Crew lavatory (L)	111
Darker (D)	78



Appendix C
Survey Results: Carrier 2

Appendix C
Survey Results: Carrier 2

Surveys sent out: 220 Surveys received: 107 (49% return)

1. What is your flightdeck position?
(there were also 5 IRP entries)

Capt.		F/O	
62	58%	45	42%

2. What aircraft are you currently operating?

MD-11	
107	100%

3. How many total flight hours have you logged?

$\bar{x}$ = 13,804
S.D. = 6,637

min 400 ⟷ max 30,000

4. How much experience do you have flying long-haul?

$\bar{x}$ = 7.06
S.D. = 7.59
yrs

min 4 mo. ⟷ max 32 yrs

5. Gender?

107 100%
male

6. Age?

$\bar{x}$ = 48.2
S.D. = 9.4

min 30 ⟷ max 59

7. What is your weight?

$\bar{x}$ = 181.8
S.D. = 21.4 lbs.

min 131 ⟷ max 230

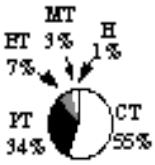
8. What is your height?

$\bar{x}$ = 70.8
S.D. = 2.1 ins.

min 66 ⟷ max 75

9. In what time-zone do you live?

Central (CT) =	59
Pacific (PT) =	36
Eastern (ET) =	8
Mountain (MT) =	3
Hawaii (HI) =	1



10. In what time-zone relative to GMT do you live?

Results were inconclusive.

11. Do you have a regular bed partner?

yes		no	
90	87%	14	13%

12. Number of children at home under 18 years of age?

No children =	71
1 or more children =	36

13. Number of others living with you?
(e.g., older children, In Laws, relatives)

Results were inconclusive.

14. Specify:

Results were inconclusive.

B. SLEEPING AT HOME

15. On your days off, what time do you usually go to sleep? (Use 24 hr. clock)

$\bar{x}$ = 22:58
S.D. = 0:55
hrs

min 21:00 ⟷ max 3:00

16. On your days off, what time do you usually get up? (Use 24 hr. clock)

$\bar{x}$ = 07:15
S.D. = 0:57
hrs

min 5:00 ⟷ max 10:00

17. On your days off, how long after going to bed do you usually take to fall asleep?

$\bar{x}$ = 17.6
S.D. = 13.9
mins

min 1 ⟷ max 60

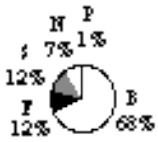
18. When sleeping at home, how many times <u>on average</u> do you wake up?

$\bar{x}$ = 1.4
S.D. = 1.1
times

min 0 ⟷ max 6

19. If you wake during the night, what is it that usually causes you to awaken?

Physiological-bathroom (B)	72
Children/spouse/pets (F)	13
Can't sleep (S)	13
Noise (N)	8
Pain (P)	1



20. If you wake during the night, on average, how long does it take you to go back to sleep?

$\bar{x}$ = 12.2
S.D. = 15.4
mins

min 1 ⟷ max 90

21. When sleeping at home, what is the usual amount of total sleep you get?

$\bar{x}$ = 7:50
S.D. = 0:47
hrs

min 6:00 ⟷ max 10:00

22. How often do you take a daytime nap at home?

never	seldom	sometimes	often	majority of time
22 (21%)	32 (30%)	36 (33%)	16 (15%)	1 (1%)

23. When sleeping at home, do you have problems getting to sleep?

never	seldom	sometimes	often	majority of time
20 (19%)	48 (44%)	35 (33%)	3 (3%)	1 (1%)

24. Please rate the following factors and indicate how much they <u>interfere with or promote</u> your sleep at home?

	interfere 1	2	no effect 3	4	promotes 5
1) quality of sleep surface	6 (6%)	8 (8%)	18 (17%)	36 (34%)	37 (35%)
2) heat	37 (35%)	39 (37%)	18 (17%)	9 (8%)	3 (3%)
3) cold	9 (8%)	20 (19%)	26 (25%)	35 (33%)	16 (15%)
4) thoughts running through head	28 (26%)	53 (50%)	22 (21%)	3 (3%)	0 (0%)
5) random noise events	23 (22%)	47 (46%)	33 (32%)	0 (0%)	0 (0%)
6) constant background noise	8 (8%)	32 (30%)	51 (47%)	8 (8%)	7 (7%)
7) background lighting	14 (13%)	41 (39%)	45 (44%)	4 (4%)	0 (0%)
8) readiness for sleep	2 (2%)	11 (10%)	10 (10%)	43 (41%)	39 (37%)
9) comfort of clothing	4 (4%)	8 (8%)	25 (24%)	45 (42%)	23 (22%)
10) low humidity/dry air	4 (4%)	22 (21%)	49 (47%)	19 (18%)	11 (10%)
11) high humidity	24 (23%)	39 (37%)	35 (33%)	7 (7%)	0 (0%)
12) trips to bathroom	21 (20%)	43 (41%)	39 (37%)	2 (2%)	0 (0%)
13) bed partner	2 (2%)	16 (16%)	52 (50%)	15 (15%)	18 (17%)
14) privacy	0 (0%)	2 (2%)	52 (50%)	19 (18%)	32 (30%)
15) ventilation	0 (0%)	3 (3%)	19 (18%)	43 (40%)	41 (39%)
16) sheets	0 (0%)	0 (0%)	32 (30%)	42 (40%)	31 (30%)
17) blankets	0 (0%)	2 (2%)	31 (30%)	48 (45%)	24 (23%)
18) pillows	0 (0%)	5 (5%)	17 (16%)	33 (31%)	51 (48%)

	interfere	promotes
19) other (specify)	Kids wake up 1	Environment 5 Mental attitude 3 Comfort 1 Physical activity 1

24. Please rate the following factors and indicate how much they interfere with or promote your sleep at home?

(results are shown as %'s of total responses in each column)

	interfere 1	2	no effect 3	4	promotes 5
1) quality of sleep surface	3.3	2.1	3.1	8.8	10.9
2) heat	20.3	10.0	3.1	2.2	0.9
3) cold	5.0	5.1	4.5	8.5	4.7
4) thoughts running through head	15.4	13.6	3.8	0.7	0.0
5) random noise events	12.6	12.0	5.8	0.0	0.0
6) constant background noise	4.4	8.2	8.9	1.9	2.1
7) background lighting	7.7	10.5	7.8	1.0	0.0
8) readiness for sleep	1.1	2.8	1.7	10.5	11.5
9) comfort of clothing	2.2	2.0	4.4	11.0	6.8
10) low humidity/dry air	2.2	5.6	8.5	4.6	3.2
11) high humidity	13.2	10.0	6.1	1.7	0.0
12) trips to bathroom	11.5	11.0	6.8	0.5	0.0
13) bed partner	1.1	4.1	9.1	3.6	5.3
14) privacy	0.0	0.5	9.1	4.6	9.4
15) ventilation	0.0	0.8	3.3	10.5	12.1
16) sheets	0.0	0.0	5.6	10.2	9.1
17) blankets	0.0	0.5	5.4	11.7	7.1
18) pillows	0.0	1.3	3.0	8.0	15.0

25. Please rate the following on the extent to which they *interfere* with your sleep at home?

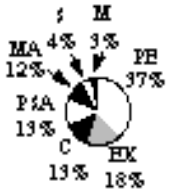
	strongly interferes 1	2	3	4	no effect 5
1) hunger	7 (7%)	17 (16%)	33 (31%)	20 (19%)	28 (27%)
2) thirst	9 (9%)	31 (30%)	34 (32%)	15 (14%)	16 (15%)
3) personal worries	14 (13%)	44 (41%)	19 (18%)	21 (20%)	8 (8%)
4) respiratory factors	3 (3%)	13 (13%)	24 (24%)	10 (10%)	52 (50%)

5) other (specify)

Noise	11
Pain	2
Mental attitude	1

26. Please list any other factors that *promote* your sleep at home.

Physical environment (PE)	48
Exercise/physical activity (EX)	23
Comfort (C)	17
Pre-sleep activities (PSA)	16
Mental attitude (MA)	15
Schedule (S)	5
Meals/food (M)	4



27. Do you take medication to help you sleep?

never	seldom	sometimes	often	majority of time
93 (87%)	0 (0%)	10 (9%)	0 (0%)	4 (4%)

28. If yes, please specify.

Cold remedies/aspirin	7
Sleeping pills	2

29. Do you ever use alcohol to help you sleep?

never	seldom	sometimes	often	majority of time
82 (77%)	16 (15%)	8 (7%)	1 (1%)	0 (0%)

30. Overall, what kind of sleeper are you?

very poor	poor	good	very good
0 (0%)	8 (7%)	58 (55%)	41 (38%)

31. Do you have a sleep problem?

yes	no
6 (6%)	100 (94%)

32. If yes, what is your sleep problem.

Restless sleeper	3
Thoughts/worries	2
Talk/Snore/Apnea	1
Bathroom	1

33. If yes, has it been diagnosed by a physician?

yes	no	no answer
2 (2%)	23 (21%)	82 (77%)

34. Has it ever prevented you from flying a scheduled trip?

yes	no	no answer
0 (0%)	48 (45%)	59 (55%)

C. SLEEPING IN AIRCRAFT BUNKS

35. How often have you used a bunk in the past 12 months?

1) current aircraft — $\bar{x}$ = 34.50, S.D. = 44.67 **times** — min 1 ⟷ max 99

2) other types of aircraft — $\bar{x}$ = 1.29, S.D. = 9.98 **times** — min 3 ⟷ max 99

36. Based on your current aircraft, which bunk do you usually sleep in?

upper	lower	either
70 (68%)	17 (17%)	15 (15%)

37. Are you able to undress for a comfortable sleep?

yes	no
87 (85%)	15 (15%)

38. Is it important for you to undress for a comfortable sleep?

yes	no
61 (60%)	41 (40%)

39. How long after getting into the bunk does it take you to fall asleep?

$\bar{x}$ = 26.52, S.D. = 19.40 **mins** — min 1 ⟷ max 120

a) What is the typical amount of sleep you get in the bunk?

$\bar{x}$ = 1:39, S.D. = 0:43 **hrs** — min 0:20 ⟷ max 3:14

b) What is the longest sleep period you have experienced in the bunk?

$\bar{x}$ = 2:48, S.D. = 1:21 **hrs** — min 0:30 ⟷ max 6:00

c) What is the shortest sleep period of time that you would use the bunk for sleep?

$\bar{x}$ = 1:04, S.D. = 0:41 **hrs** — min 0:05 ⟷ max 3:00

40. When you have an opportunity to use the bunk how often do you experience difficulty sleeping?

never	seldom	sometimes	often	majority of time
9 (9%)	27 (26%)	34 (33%)	19 (19%)	13 (13%)

a) How often do you use the bunk only for rest and not sleep?

never	seldom	sometimes	often	majority of time
28 (28%)	20 (19%)	29 (28%)	19 (18%)	7 (7%)

41. Are you required to spend some time in the bunk when not flying?

yes	no
5 (5%)	102 (95%)

42. If yes, who or what mandates use? Results were inconclusive.

43. What other factors determine bunk use and rostering?

Seniority/crew decision (S)	35
Sleep/circadian factors (C)	12
Length of flight (L)	9
Concern with flight/operations (F)	5
Augmentation (A)	4

44. In general, what percentage of cruise time is made available to you for using the bunk?

$\bar{x}$ = 37.85
S.D. = 19.83 %

min 14 ⟷ max 99

45. Rate your overall attitude about the bunk.

very neg	neg	neutral	pos	very pos
0 (0%)	4 (4%)	9 (9%)	24 (23%)	67 (64%)

46. How does bunk sleep affect your overall alertness?

very decreased alertness	decreased alertness	no change	improved alertness	very improved alertness
0 (0%)	0 (0%)	2 (2%)	44 (43%)	56 (55%)

47. How does bunk sleep affect your overall performance?

very decreased performance	decreased performance	no change	improved performance	very improved performance
0 (0%)	0 (0%)	3 (3%)	54 (53%)	44 (44%)

48. How often can you sleep when you use any of the following.

	never	seldom	sometimes	often	almost always
1) cockpit seat	55 (53%)	25 (25%)	14 (14%)	3 (3%)	5 (5%)
2) 1st class seat	10 (10%)	30 (29%)	38 (36%)	17 (16%)	9 (9%)
3) passenger seat	43 (44%)	34 (35%)	17 (17%)	2 (2%)	2 (2%)
4) bunk	2 (2%)	3 (3%)	13 (13%)	32 (31%)	54 (51%)
5) at home in bed	0 (0%)	0 (0%)	0 (0%)	5 (5%)	99 (95%)

49. Please rate the following factors and indicate how much they interfere with or promote your sleep in the bunk?

	interfere 1	2	no effect 3	4	promotes 5
1) quality of sleep surface	7 (7%)	34 (34%)	18 (17%)	18 (17%)	26 (25%)
2) heat	31 (30%)	38 (37%)	22 (22%)	9 (9%)	2 (2%)
3) cold	9 (9%)	21 (21%)	34 (33%)	24 (24%)	13 (13%)

4) thoughts running through head	20	20%	55	54%	27	26%	0	0%	0	0%
5) random noise events	47	46%	37	36%	18	18%	0	0%	0	0%
6) constant background noise	7	7%	34	33%	43	42%	12	12%	6	6%
7) background lighting	11	11%	27	26%	58	56%	4	4%	3	3%
8) readiness for sleep	0	0%	15	15%	11	11%	40	39%	36	35%
9) comfort of clothing	0	0%	11	11%	24	24%	39	38%	27	27%
10) low humidity/dry air	9	9%	20	19%	45	44%	23	22%	6	6%
11) trips to bathroom	35	35%	34	34%	29	29%	2	2%	0	0%
12) someone in the other bunk	3	3%	17	17%	82	80%	0	0%	0	0%
13) seat belt sign	2	2%	15	15%	84	83%	0	0%	0	0%
14) turbulence	8	8%	60	58%	30	29%	2	2%	3	3%
15) privacy	0	0%	11	11%	45	44%	20	20%	25	25%
16) bunk size	4	4%	16	16%	35	34%	26	26%	20	20%
17) facility size	3	3%	13	13%	43	42%	27	26%	16	16%
18) headspace	6	6%	22	22%	38	36%	25	25%	11	11%
19) lighting	6	6%	17	17%	55	52%	16	16%	9	9%
20) ventilation	7	7%	19	19%	17	17%	40	40%	17	17%
21) storage space	0	0%	3	3%	79	76%	17	17%	4	4%
22) curtains	0	0%	0	0%	27	27%	40	39%	34	34%
23) sheets	2	2%	5	5%	50	52%	21	21%	20	20%
24) blankets	0	0%	3	3%	23	22%	42	41%	35	34%
25) pillows	3	3%	4	4%	14	14%	31	30%	51	49%

interfere **promotes**

26) other (specify)

Noise	11
Head tilts down	4

Fast cockpit access	1
Clean linens	1
Use alarm	1

49. Please rate the following factors and indicate how much they interfere with or promote your sleep in the bunk?

(results are shown as %'s of total responses in each column)

	interfere 1	2	no effect 3	4	promotes 5
1) quality of sleep surface	3.0	6.4	1.9	3.8	7.0
2) heat	13.4	7.1	2.3	1.9	0.5
3) cold	3.9	3.9	3.6	5.0	3.5
4) thoughts running through head	8.6	10.3	2.8	0.0	0.0
5) random noise events	20.3	6.9	1.9	0.0	0.0
6) constant background noise	3.0	6.4	4.5	2.5	1.6
7) background lighting	4.7	5.1	6.1	0.8	0.8
8) readiness for sleep	0.0	2.8	1.1	8.4	9.8
9) comfort of clothing	0.0	2.1	2.5	8.2	7.3
10) low humidity/dry air	3.9	3.8	4.7	4.8	1.6
11) trips to bathroom	15.1	6.4	3.0	0.4	0.0
12) bunk partner	1.3	3.2	8.6	0.0	0.0
13) seat belt sign	0.8	2.8	8.8	0.0	0.1
14) turbulence	3.4	11.3	3.2	0.4	0.8
15) privacy	0.0	2.1	4.7	4.2	6.8
16) bunk size	1.7	3.0	3.7	5.4	5.4
17) facility size	1.3	2.4	4.5	5.6	4.3
18) headspace	2.6	4.1	4.0	5.2	3.0
19) lighting	2.6	3.2	5.8	3.3	2.4
20) ventilation	3.0	3.6	1.8	8.4	4.6
21) storage space	0.0	0.6	8.3	3.6	1.1
22) curtains	0.0	0.0	2.8	8.4	9.2
23) sheets	0.9	0.9	5.3	4.4	5.4
24) blankets	0.0	0.6	2.4	8.8	9.5
25) pillows	1.3	0.8	1.5	6.5	13.8

50. Please rate the following on the extent to which they <u>interfere</u> with your sleep in the bunk?

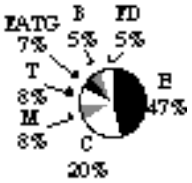
	strongly interferes 1		2		3		4		no effect 5	
1) hunger	7	7%	15	15%	22	22%	15	15%	43	41%
2) thirst	7	7%	29	28%	27	27%	15	15%	23	23%
3) claustrophopia	2	2%	8	8%	19	19%	7	7%	65	64%
4) personal worries	7	7%	21	21%	27	28%	22	22%	22	22%
5) respiratory factors	0	0%	8	8%	19	19%	4	4%	68	69%

6) other (specify)

Noise	17
F/As smoking	5
Environment	4
Ready for duty	2

51. Please list any other factors that <u>promote</u> good sleep in the bunk.

Environment (E)	34
Comfort (C)	15
Ease of mind (M)	6
Lack of turbulence (T)	6
Fatigue (FATG)	5
Length of break (B)	4
Food (FD)	4



52. When using the bunk, do you do anything to help you get to sleep or to minimize disturbance of your sleep, such as:

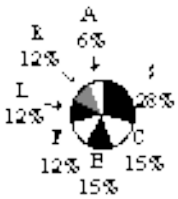
	yes		no	
1) Wear earplugs?	20	20%	82	80%
2) Wear eyeshades?	3	3%	98	97%
3) Listen to music?	6	6%	96	94%
4) Relaxation techniques?	24	24%	74	76%

5) Other (specify)

Read	6
Make dark	2

53. Describe any <u>pre-trip</u> strategies you use to help you sleep in the bunk.

Schedule sleep (S)	10
Avoid caffeine (C)	5
Exercise (E)	5
Limit food intake (F)	4
Limit liquids (L)	4
Rest (R)	4
Bring comfort aids (A)	2



54. Please suggest how the crew rest facility can be improved to be more conducive to sleep?

Location/away from galley (LC)	34
Comfort (C) (mattress, pillows, sheets, blankets)	27
Humidifier/temperature control (T)	20
Sound proofing (S)	17
F/As quieter (F)	10
Crew lavatory (LV)	7
Head forward (H)	6
Music access (M)	3
Larger bunk area (A)	2

Appendix D
Survey Results: Carrier 3

Appendix D
Survey Results: Carrier 3

Surveys sent out: 1500 Surveys received: 560 (37% return)

1. What is your flightdeck position?

Capt.	F/O	S/O or F/E	IRP
171 (32%)	295 (54%)	68 (13%)	4 (1%)

2. What aircraft are you currently operating?

B747 series	B747-400
258 (47%)	290 (53%)

3. How many total flight hours have you logged?

$\bar{x}$ = 15,012
S.D. = 6,796

min 100 ⟷ max 38000

4. How much experience do you have flying long-haul?

$\bar{x}$ = 8.60
S.D. = 9.39
yrs

min 1 mo. ⟷ max 40 yrs.

5. Gender?

male	female
541 (98%)	9 (2%)

6. Age?

$\bar{x}$ = 51.2
S.D. = 8.3

min 27 ⟷ max 73

7. What is your weight?

$\bar{x}$ =184.1
S.D. = 24.5 lbs.

min 105 ⟷ max 280

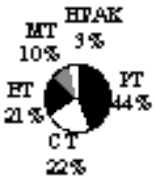
8. What is your height?

$\bar{x}$ = 70.7
S.D. = 2.7 ins.

min 62 ⟷ max 81

9. In what time-zone do you live?

Pacific (PT) =	237
Eastern (ET) =	117
Mountain (MT) =	115
Central (CT) =	54
Hawaii/Alaska (HI/AK) =	17



10. In what time-zone relative to GMT do you live?

Results were inconclusive.

11. Do you have a regular bed partner?

yes	no
482 (88%)	66 (12%)

12. Number of children at home under 18 years of age?

No children =	353
1 or more children =	196

13. Number of others living with you?
(e.g., older children, In Laws, relatives)

Results were inconclusive.

14. Specify:

Results were inconclusive.

B. SLEEPING AT HOME

15. On your days off, what time do you usually go to sleep? (Use 24 hr. clock)

$\bar{x}$ = 23:01
S.D. = 0:56
hrs

min 2000 ⟷ max 0330

16. On your days off, what time do you usually get up? (Use 24 hr. clock)

$\bar{x}$ = 07:21
S.D. = 0:58
hrs

min 0418 ⟷ max 1030

17. On your days off, how long after going to bed do you usually take to fall asleep?

$\bar{x}$ = 20.5
S.D. = 17.7
mins

min 1 ⟷ max 180

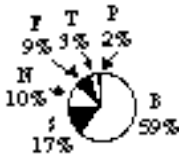
18. When sleeping at home, how many times <u>on average</u> do you wake up?

$\bar{x}$ = 1.5
S.D. = 1.1
times

min 0 ⟷ max 6

19. If you wake during the night, what is it that usually causes you to awaken?

Physiological (B) (bathroom)	312
Can't sleep (S)	87
Noise (N)	51
Children/spouse/pets (F)	48
Thirst (T)	14
Pain (P)	10



20. If you wake during the night, on average, how long does it take you to go back to sleep?

$\bar{x}$ = 15.2
S.D. = 19.3
mins

min 1 ⟷ max 180

21. When sleeping at home, what is the usual amount of total sleep you get?

$\bar{x}$ = 7:50
S.D. = 0:49
hrs

min 4:00 ⟷ max 10:00

22. How often do you take a daytime nap at home?

never	seldom	sometimes	often	majority of time
109 (20%)	168 (30%)	188 (34%)	78 (14%)	11 (2%)

23. When sleeping at home, do you have problems getting to sleep?

never	seldom	sometimes	often	majority of time
66 (12%)	263 (48%)	195 (35%)	22 (4%)	8 (1%)

24. Please rate the following factors and indicate how much they <u>interfere with or promote</u> your sleep at home?

	interfere 1	2	no effect 3	4	promotes 5
1) quality of sleep surface	20 (4%)	52 (9%)	65 (12%)	184 (33%)	232 (42%)
2) heat	160 (29%)	233 (43%)	83 (15%)	48 (9%)	20 (4%)
3) cold	36 (7%)	120 (22%)	125 (23%)	188 (34%)	78 (14%)
4) thoughts running through head	215 (39%)	246 (44%)	79 (14%)	10 (2%)	3 (1%)
5) random noise events	144 (26%)	269 (49%)	133 (24%)	5 (1%)	2 (0%)
6) constant background noise	73 (13%)	164 (30%)	232 (42%)	65 (12%)	18 (3%)
7) background lighting	100 (18%)	220 (41%)	198 (37%)	19 (3%)	8 (1%)
8) readiness for sleep	24 (4%)	56 (10%)	68 (12%)	183 (33%)	218 (41%)
9) comfort of clothing	16 (3%)	47 (9%)	188 (34%)	173 (32%)	122 (22%)
10) low humidity/dry air	81 (15%)	147 (27%)	214 (38%)	78 (14%)	31 (6%)
11) high humidity	111 (20%)	214 (39%)	259 (29%)	56 (10%)	12 (2%)
12) trips to bathroom	102 (18%)	270 (49%)	171 (31%)	6 (1%)	3 (1%)
13) bed partner	16 (3%)	92 (17%)	264 (48%)	106 (19%)	73 (13%)
14) privacy	14 (3%)	38 (7%)	207 (36%)	158 (29%)	136 (25%)
15) ventilation	10 (2%)	43 (8%)	83 (15%)	233 (42%)	183 (33%)
16) sheets	6 (1%)	12 (2%)	136 (25%)	241 (43%)	158 (29%)
17) blankets	9 (1%)	26 (5%)	129 (23%)	256 (46%)	132 (24%)
18) pillows	10 (2%)	24 (4%)	61 (11%)	211 (38%)	245 (45%)

	interfere	promotes
19) other (specify)	No substantial findings	Environment 26 Mental attitude 15 Physical activity 12 Comfort 7

24. Please rate the following factors and indicate how much they interfere with or promote your sleep at home?

(results are shown as %'s of total responses in each column)

	interfere 1	2	no effect 3	4	promotes 5
1) quality of sleep surface	1.7	2.3	2.5	8.3	13.7
2) heat	13.7	10.2	3.2	2.1	1.2
3) cold	3.1	5.3	4.8	8.4	4.6
4) thoughts running through head	18.4	10.8	3.0	0.4	0.2
5) random noise events	12.3	11.8	5.1	0.2	0.1
6) constant background noise	6.2	7.2	8.9	2.9	1.1
7) background lighting	8.6	9.6	7.6	0.9	0.5
8) readiness for sleep	2.1	2.5	2.6	8.2	12.8
9) comfort of clothing	1.4	2.1	7.2	7.8	7.2
10) low humidity/dry air	6.9	6.4	8.2	3.5	1.8
11) high humidity	9.5	9.4	6.1	2.5	0.7
12) trips to bathroom	8.7	11.8	6.5	0.3	0.2
13) bed partner	1.4	4.0	10.1	4.7	4.3
14) privacy	1.2	1.7	7.9	7.1	8.0
15) ventilation	0.9	1.9	3.2	10.5	10.8
16) sheets	0.5	0.5	5.2	10.8	9.3
17) blankets	0.8	1.1	4.9	11.5	7.8
18) pillows	0.8	1.1	2.3	9.5	14.4

25. Please rate the following on the extent to which they *interfere* with your sleep at home?

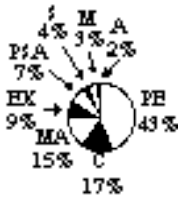
	strongly interferes 1	2	3	4	no effect 5
1) hunger	27 (5%)	152 (27%)	153 (28%)	95 (17%)	125 (23%)
2) thirst	45 (10%)	224 (51%)	24 (5%)	83 (19%)	67 (15%)
3) personal worries	134 (24%)	215 (40%)	100 (18%)	72 (13%)	29 (5%)
4) respiratory factors	32 (6%)	89 (17%)	132 (25%)	55 (10%)	229 (42%)

5) other (specify)

Noise	23
Mental attitude	9
Family/pets	5
Environment	3

26. Please list any other factors that *promote* your sleep at home.

Physical environment (PE)	379
Comfort (C)	144
Mental attitude (MA)	128
Exercise/physical activity (EX)	80
Pre-sleep activities (PSA)	62
Schedule (S)	36
Meals/food (M)	25
Alcohol/medication (A)	17



27. Do you take medication to help you sleep?

never	seldom	sometimes	often	majority of time
442 (80%)	68 (12%)	36 (7%)	4 (1%)	2 (0%)

28. If yes, please specify.

Cold remedies/aspirin	62
Sleeping pills	25
Allergy medication	4

29. Do you ever use alcohol to help you sleep?

never	seldom	sometimes	often	majority of time
393 (71%)	83 (15%)	56 (10%)	14 (3%)	5 (1%)

30. Overall, what kind of sleeper are you?

very poor	poor	good	very good
6 (1%)	50 (9%)	303 (55%)	192 (35%)

31. Do you have a sleep problem?

yes	no
77 (14%)	474 (86%)

32. If yes, what is your sleep problem.

Restless sleeper	26
Circadian disruption	17
Thoughts/worries	9
Talk/Snore/Apnea	7
Pain	4
Bathroom	4

33. If yes, has it been diagnosed by a physician?

yes	no	no answer
12 (2%)	145 (26%)	395 (72%)

34. Has it ever prevented you from flying a scheduled trip?

yes	no	no answer
15 (3%)	253 (46%)	284 (51%)

C. SLEEPING IN AIRCRAFT BUNKS

35. How often have you used a bunk in the past 12 months?

1) current aircraft — $\bar{x}$ = 25.86, S.D. = 22.16 **times** — min 1 ⟷ max 99

2) other types of aircraft — $\bar{x}$ = 19.59, S.D. = 23.74 **times** — min 1 ⟷ max 99

36. Based on your current aircraft, which bunk do you usually sleep in?

upper	lower	either
88 (17%)	262 (49%)	183 (34%)

37. Are you able to undress for a comfortable sleep?

yes	no
384 (71%)	156 (29%)

38. Is it important for you to undress for a comfortable sleep?

yes	no
400 (74%)	137 (26%)

39. How long after getting into the bunk does it take you to fall asleep?

$\bar{x}$ = 42.29, S.D. = 36.60 **mins** — min 1 ⟷ max 300

a) What is the <u>typical amount</u> of sleep you get in the bunk?

$\bar{x}$ = 2:22, S.D. = 1:22 **hrs** — min 0:10 ⟷ max 7:00

b) What is the <u>longest sleep period</u> you have experienced in the bunk?

$\bar{x}$ = 3:39, S.D. = 1:46 **hrs** — min 0:10 ⟷ max 10:00

c) What is the <u>shortest sleep period</u> of time that you would use the bunk for sleep?

$\bar{x}$ = 1:15, S.D. = 0:54 **hrs** — min 0:01 ⟷ max 6:00

40. When you have an opportunity to use the bunk how often do you experience difficulty sleeping?

never	seldom	sometimes	often	majority of time
15 (3%)	92 (17%)	167 (31%)	143 (26%)	126 (23%)

a) How often do you use the bunk only for rest and not sleep?

never	seldom	sometimes	often	majority of time
106 (20%)	160 (29%)	131 (24%)	79 (15%)	67 (12%)

41. Are you required to spend <u>some</u> time in the bunk when not flying?

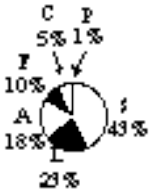
yes		no	
35	7%	500	93%

42. If yes, who or what mandates use?

Results were inconclusive.

43. What other factors determine bunk use and rostering?

Seniority/crew decision (S)	162
Length of flight (L)	87
Augmentation (A)	70
Schedule/flight operations (F)	40
Sleep/circadian factors (C)	21
Prefer alternate choice (P)	4



44. In general, what percentage of cruise time is made available to you for using the bunk?

$\bar{x}$ = 34.18
S.D. = 13.80 %

min 2 ⟷ max 99

45. Rate your overall attitude about the bunk.

very neg		neg		neutral		pos		very pos	
16	3%	51	9%	76	14%	209	39%	193	35%

46. How does bunk sleep affect your overall alertness?

very decreased alertness		decreased alertness		no change		improved alertness		very improved alertness	
5	1%	15	3%	31	6%	329	59%	168	31%

47. How does bunk sleep affect your overall performance?

very decreased performance		decreased performance		no change		improved performance		very improved performance	
4	1%	12	2%	40	7%	349	64%	141	26%

48. How often can you sleep when you use any of the following.

	never		seldom		sometimes		often		almost always	
1) cockpit seat	217	41%	165	31%	109	20%	35	6%	13	2%
2) 1st class seat	48	9%	137	25%	186	34%	131	24%	42	8%
3) passenger seat	132	24%	234	43%	123	23%	37	7%	17	3%
4) bunk	9	2%	30	5%	111	20%	181	33%	216	40%
5) at home in bed	0	0%	0	0%	0	0%	25	5%	521	95%

49. Please rate the following factors and indicate how much they interfere with or promote your sleep in the bunk?

	interfere 1	2	no effect 3	4	promotes 5
1) quality of sleep surface	50 (9%)	124 (23%)	65 (12%)	160 (30%)	142 (26%)
2) heat	162 (30%)	231 (42%)	68 (13%)	66 (12%)	17 (3%)
3) cold	61 (10%)	180 (11%)	104 (33%)	145 (19%)	54 (27%)
4) thoughts running through head	180 (33%)	265 (48%)	87 (16%)	11 (2%)	3 (1%)
5) random noise events	238 (44%)	239 (44%)	66 (12%)	0 (0%)	0 (0%)
6) constant background noise	79 (14%)	168 (31%)	207 (38%)	72 (13%)	20 (4%)
7) background lighting	103 (19%)	235 (43%)	184 (34%)	14 (3%)	8 (1%)
8) readiness for sleep	47 (9%)	79 (14%)	32 (6%)	189 (35%)	198 (36%)
9) comfort of clothing	36 (7%)	66 (12%)	106 (19%)	227 (42%)	111 (20%)
10) low humidity/dry air	97 (18%)	194 (35%)	181 (33%)	52 (10%)	20 (4%)
11) trips to bathroom	172 (32%)	228 (41%)	146 (27%)	0 (0%)	0 (0%)
12) someone in the other bunk	13 (2%)	97 (18%)	436 (80%)	0 (0%)	0 (0%)
13) seat belt sign	26 (5%)	79 (15%)	437 (80%)	0 (0%)	0 (0%)
14) turbulence	198 (36%)	272 (49%)	63 (12%)	10 (2%)	3 (1%)
15) privacy	28 (5%)	84 (15%)	248 (46%)	87 (16%)	96 (18%)
16) bunk size	47 (9%)	156 (28%)	154 (28%)	101 (19%)	85 (16%)
17) facility size	41 (8%)	108 (20%)	230 (41%)	107 (20%)	58 (11%)
18) headspace	43 (8%)	125 (23%)	227 (41%)	91 (17%)	58 (11%)
19) lighting	57 (11%)	140 (26%)	242 (44%)	70 (13%)	31 (6%)
20) ventilation	28 (5%)	107 (20%)	93 (18%)	203 (37%)	107 (20%)
21) storage space	19 (4%)	39 (7%)	427 (79%)	44 (8%)	12 (2%)
22) curtains	25 (5%)	47 (9%)	87 (16%)	172 (31%)	216 (39%)

23) sheets	28 (5%)	64 (12%)	108 (20%)	180 (33%)	165 (30%)
24) blankets	28 (5%)	57 (10%)	68 (12%)	200 (38%)	193 (35%)
25) pillows	57 (10%)	72 (13%)	30 (5%)	142 (26%)	246 (46%)

26) other (specify)	interfere		promotes	
	Noise	24	Comfort (bedding)	25
			Positive mental attitude	4

49. Please rate the following factors and indicate how much they <u>interfere with or promote</u> your sleep in the bunk?

(results are shown as %'s of total responses in each column)

	interfere 1	2	no effect 3	4	promotes 5
1) quality of sleep surface	2.6	3.6	1.6	6.8	7.6
2) heat	8.5	6.7	1.7	2.8	0.9
3) cold	3.2	5.2	2.5	6.2	2.9
4) thoughts running through head	9.5	7.6	2.1	0.5	0.2
5) random noise events	12.5	6.9	1.6	0.0	0.0
6) constant background noise	4.2	4.8	5.0	3.1	1.1
7) background lighting	5.4	6.8	4.5	0.6	0.4
8) readiness for sleep	2.5	2.3	0.8	8.0	10.5
9) comfort of clothing	1.9	1.9	2.6	9.7	5.9
10) low humidity/dry air	5.1	5.6	4.4	2.2	1.1
11) trips to bathroom	9.1	6.6	3.6	0.0	0.0
12) bunk partner	0.7	2.8	10.6	0.0	0.0
13) seat belt sign	1.4	2.3	10.5	0.0	0.0
14) turbulence	10.4	7.8	1.5	0.4	0.2
15) privacy	1.5	2.4	6.0	3.7	5.1
16) bunk size	2.5	4.5	3.8	4.3	4.5
17) facility size	2.2	3.1	5.6	4.6	3.1
18) headspace	2.3	3.6	5.5	3.9	3.1
19) lighting	3.0	4.0	5.9	3.0	1.6
20) ventilation	1.5	3.1	2.4	8.6	5.7
21) storage space	1.0	1.1	10.4	1.9	0.6
22) curtains	1.3	1.4	2.1	7.3	11.5
23) sheets	1.5	1.8	2.6	7.6	8.8
24) blankets	1.5	1.6	1.7	8.5	10.3
25) pillows	3.0	2.1	0.7	6.0	13.1

50. Please rate the following on the extent to which they <u>interfere</u> with your sleep in the bunk?

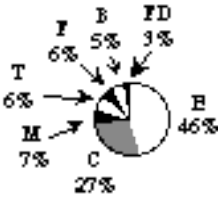
	strongly interferes 1	2	3	4	no effect 5
1) hunger	30 (6%)	148 (27%)	138 (25%)	90 (17%)	137 (25%)
2) thirst	41 (8%)	191 (35%)	142 (26%)	73 (13%)	96 (18%)
3) claustrophopia	9 (2%)	36 (7%)	138 (25%)	40 (7%)	319 (59%)
4) personal worries	75 (14%)	149 (28%)	143 (26%)	92 (17%)	83 (15%)
5) respiratory factors	16 (3%)	55 (10%)	139 (26%)	46 (9%)	277 (52%)

6) other (specify)

Noise	40
Bathroom	21
Scheduling	15
Bunk comfort	14
Turbulence	11
Mental attitude	11
Environment	7

51. Please list any other factors that <u>promote</u> good sleep in the bunk.

Environment (E)	342
Comfort (C)	206
Ease of mind (M)	56
Lack of turbulence (T)	49
Fatigue (FATG)	46
Length of break (B)	34
Food (FD)	22



52. When using the bunk, do you do anything to help you get to sleep or to minimize disturbance of your sleep, such as:

	yes	no
1) Wear earplugs?	171 (44%)	360 (44%)
2) Wear eyeshades?	62 (12%)	462 (88%)
3) Listen to music?	93 (18%)	431 (82%)
4) Relaxation techniques?	157 (31%)	351 (69%)

5) Other (specify)

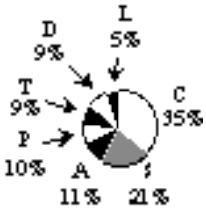
Read	61
Comfortable clothing	23

53. Describe any <u>pre-trip</u> strategies you use to help you sleep in the bunk.

Schedule sleep (S)	219
Avoid caffeine (C)	56
Exercise (E)	38
Limit food intake (F)	35
Rest (R)	26
Limit liquids (L)	26
Bring comfort aids (A)	21
Settle problems (P)	12

54. Please suggest how the crew rest facility can be improved to be more conducive to sleep?

Comfort (C) (mattress,pillows,sheets,blankets)	312
Sound proofing (S)	187
Larger bunk area (A)	93
Privacy (P)	87
Humidifier/temperature control (T)	78
Darker (D)	76
Crew lavatory (L)	43



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13. ABSTRACT *(Maximum 200 words)*

Many aircraft operated on long-haul commercial airline flights are equipped with on-board crew rest facilities, or bunks, to allow crewmembers to rest during the flight. The primary objectives of this study were to gather data on how the bunks were used, the quantity and quality of sleep obtained by flight crewmembers in the facilities, and the factors that affected their sleep. A retrospective survey comprising 54 questions of varied format addressed demographics, home sleep habits, and bunk sleep habits. Crewmembers from three airlines with long-haul fleets carrying augmented crews consisting of B747-100/200, B747-400, and MD-11 aircraft equipped with bunks returned a total of 1404 completed surveys (a 37% response rate). Crewmembers from the three carriers were comparable demographically, although one carrier had older, more experienced flight crewmembers. Each group, on average, rated themselves as “good” or “very good” sleepers at home, and all groups obtained about the same average amount of sleep each night. Most were able to sleep in the bunks, and about two thirds indicated that these rest opportunities benefited their subsequent flight deck alertness and performance. Comfort, environment, and physiology (e.g., being ready for sleep) were identified as factors that most promoted sleep. Factors cited as interfering with sleep included random noise, thoughts, heat, and the need to use the bathroom. These factors, in turn, suggest potential improvements to bunk facilities and their use. Ratings of the three aircraft types suggested differences among facilities. Bunks in the MD-11 were rated significantly better than either of the B747 types, and the B747-400 bunks received better ratings than did the older, B747-100/200 facilities.

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